U.S. Department of Energy

Oakland Operations Office, Oakland, California

FINAL ENGINEERING EVALUATION/ COST ANALYSIS FOR THE WESTERN AND EASTERN DOG PENS

at the

LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH
UNIVERSITY OF CALIFORNIA, DAVIS

Prepared for:

United States Department of Energy
Oakland Operations Office
1301 Clay Street
Oakland, California 94612-5208

Prepared by:

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February 23, 2001
Rev. 0

DOE Oakland Operations Contract DE-AC03-96SF20686

Weiss Associates
Environmental Science, Engineering and Management

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CONTENTS

TABLES

FIGURES

APPENDICES

ACRONYMS AND ABBREVIATIONS

1D	one-dimensional
ARARs	Applicable or Relevant and Appropriate Requirements
bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
cfs	cubic feet per second
cm/sec	centimeters per second
cm^2	square centimeters
Co-60	cobalt-60
COPC	constituent of potential concern
Cr-VI	hexavalent chromium
Cs-137	cesium-137
CVRWQCB	Central Valley Regional Water Quality Control Board
DCG	Derived Concentration Guide
DOE	U.S. Department of Energy
dpm	disintegrations per minute
EA	Environmental Assessment
EDPs	Eastern Dog Pens
EE/CA	Engineering Evaluation/Cost Analysis
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Administration

Freon-12	dichlorodifluoromethane
ft	feet
HI	hazard index
HSP	Health and Safety Procedure
HSU	hydrostratigraphic unit
I-80	U.S. Interstate Highway 80
ITEH	Institute for Toxicology and Environmental Health
LEHR	Laboratory for Energy-Related Health Research
LF	Landfill
mg/kg	milligram per kilogram
MOA	Memorandum of Agreement
mrem/yr	millirem per year
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NPL	National Priority List
NRC	Nuclear Regulatory Commission
NUFT	Non-Isothermal, Unsaturated Flow and Transport
Pb-210	lead-210
pCi/g	picoCurie per gram
PM_{10}	particulate matter less than 10 microns in diameter
PNNL	Pacific Northwest National Laboratory
RA	removal action
Ra/Sr	Radium/Strontium

Ra-226	radium-226
RAO	removal action objective
RBAS	Risk-Based Action Standards
RME	reasonable maximum exposure
RNG	random number generator
ROD	Record of Decision
RPM	Remedial Project Manager
SOP	Standard Operating Procedure
SQP	Standard Quality Procedure
Sr-90	strontium-90
SVOC	semi-volatile organic compound
TBCs	To-Be-Considered guidelines
Th-234	thorium-234
TSCA	Toxic Substances Control Act
U-238	uranium-238
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
VOC	volatile organic compound
WDPs	Western Dog Pens
WRS	Wilcoxon Rank Sum
µCi	microCurie
µCi/yr	microCuries per year
µg/kg	micrograms per kilogram
µg/yr	micrograms per year

SUMMARY

This Engineering Evaluation/Cost Analysis (EE/CA) fulfills the requirements of Section 300.415 (b)(4)(I) of the National Contingency Plan (NCP) for the proposed non-time critical removal actions (RAs) at the former Dog Pens areas at the Laboratory for Energy-Related Health Research (LEHR, Site) located at the University of California, Davis (UC Davis).

The primary objective of this EE/CA is to determine the most suitable RAs for two U.S. Department of Energy (DOE) areas located within the Site known as the Former Western Dog Pens (WDPs) and Former Eastern Dog Pens (EDPs). From 1958 to the mid-1980s, the Former Dog Pens (Dog Pens) were used to house beagles that were subjects of research focusing on the health effects of chronic radiation exposure. During this period, excreta containing residual levels of radionuclides and pesticides used for flea control may have impacted the dog pen areas.

Several investigations have been conducted in the past ten years to characterize the Dog Pens. As discussed in Section 3, statistical evaluation of Dog Pens data indicate that constituents of concern in soil beneath the Dog Pens are below the risk-based target levels. Therefore, soil removal and disposal are not addressed in this EE/CA. However, the analytical data for the gravel, asphalt and concrete curbs that comprise the Dog Pens are not sufficient to eliminate them as potential risks, and thus they are evaluated in this EE/CA.

This EE/CA establishes the following removal action objectives (RAOs) for the Dog Pens:

- Mitigate potential excess cumulative cancer risk to an individual from exposure to Site contaminants to a level within a nominal range of 10^{-4} to 10^{-6}, using 10^{-6} as the point of departure;
- Reduce potential non-cancer hazard indices (HIs) to levels below 1;
- Mitigate present and potential future impact to ground water;
- Mitigate potential ecological risks during and after the RAs;
- Minimize impact to Site university research; and,
- Facilitate UC Davis' remediation of the landfill underlying the EDPs.

This EE/CA follows the protocol recommended by the NCP and U.S. Environmental Protection Agency (EPA) guidance to select the most suitable RA alternative for each DOE area. This involves: 1) screening potentially applicable remedial technologies, 2) developing RA alternatives from the retained remedial technologies, 3) evaluating the alternatives and 4) recommending a preferred alternative for each area.

The WDPs alternatives are:

- Alternative 1: No Action (only includes site inspections);
- Alternative 2: Implement institutional controls; or,
- Alternative 3: Remove and dispose concrete curbs, gravel and asphalt.

The EDPs alternatives are:

- Alternative 1: No Action (only includes site inspections);
- Alternative 2: Implement institutional controls;
- Alternative 3: Remove and dispose concrete curbs; or,
- Alternative 4: Remove and dispose concrete curbs, gravel and asphalt.

The alternatives were evaluated for effectiveness, implementability and cost according to EPA guidance. This evaluation is summarized below.

For the WDPs:

- Alternative 1 does not meet Applicable or Relevant and Appropriate Requirements (ARARs) or protect human health and the environment. Although implementable, Alternative 1 is not effective and does not meet the RAOs because it takes no action to limit site access or prevent contaminant disturbance.
- Alternative 2 is implementable and more effective than Alternative 1 for preventing contaminant exposure and meets all ARARs. However, there is significant uncertainty associated with unforeseen events during the 100-year monitoring period that could cause the costs of this alternative to increase significantly and long-term enforcement would require vigilance from local regulatory bodies.
- Alternative 3 is effective, implementable and meets all ARARs. This alternative is the most effective in the long term because it eliminates potential impacts to the public and the environment by physically removing contaminants from the Site. Alternative 3 is technically feasible and utilizes available resources.

For the EDPs:

- As with the WDPs, Alternative 1 does not meet ARARs or protect human health and the environment. Alternative 1 is not effective because it takes no action to limit site access or prevent contaminant disturbance.
- Alternative 2 is implementable and is more effective than Alternative 1 for preventing public and environmental exposure to contaminants. Assuming that the underlying landfill will be remediated, this alternative adequately protects human health and the environment. However, long-term enforcement of institutional controls would require vigilance from local regulatory bodies.

- Alternative 3 is effective because it removes a potential contaminant source and facilitates remediation of the underlying landfill. However, it is five to twenty times more expensive than Alternatives 1 and 2 and would be difficult to implement due to the proximity of landfill waste to the EDPs. Land use restrictions would still apply.
- Alternative 4 is also effective, because it removes a potential contaminant source and facilitates remediation of the underlying landfill. However, it costs 40% more than Alternative 3, and would be difficult to implement due to the proximity of landfill waste to the EDPs. Land use restrictions would still apply pending remediation of the underlying landfill.

From this evaluation, Alternative 3 for the WDPs and Alternative 2 for the EDPs were selected as the preferred alternatives. Concrete curbs, gravel and asphalt removal is recommended for the WDPs because it releases almost three acres of land for beneficial use and has a predictable endpoint, whereas there is significant uncertainty associated with the 100-year period associated with the other WDPs alternatives.

Alternative 2 is recommended for the EDPs, because it adequately protects the public and the environment from potential exposure to contaminants pending remediation of the underlying landfill and costs significantly less than Alternatives 3 and 4.

This EE/CA also includes an assessment of the environmental effects of each of the proposed alternatives in accordance with National Environmental Policy Act (NEPA) guidance. Evaluation of the likely environmental impacts associated with each of the alternatives indicates that there would be either no impact or minimal impact to the environment should any of the alternatives be selected. There are five environmental considerations that are not expected to be impacted at all: wetlands, aesthetics and scenic values, socioeconomic conditions, historical and cultural resources and land use. Short-term, minimal impacts would occur for water resources, biological resources, air quality, noise, occupational and public health considerations and transportation of low-level radioactive waste. These impacts are expected to be short-term, minimal and fully mitigated by compliance with existing regulations. Most impacts (such as dust and noise) would be limited to the Site and immediate surroundings and are expected to have no lasting consequences. No long-term, significant, or adverse environmental impacts are likely to occur from any of the alternatives proposed and evaluated in this EE/CA.

Although the RAs described in this document are not an official final remedy for DOE areas, it is anticipated and intended that these DOE areas will not require further remedial actions in the future. Land use covenants will be required in accordance with applicable statutes and regulations if future risk assessment indicates a need for them. In addition, the final Record of Decision (ROD) for the Site will determine compliance with future (not yet established) ARARs and RAOs based on hazards posed by all areas including the UC Davis areas not addressed in this EE/CA. The need for potential future remedial actions at the Dog Pens will be determined when the ROD is developed.

1. INTRODUCTION, OBJECTIVES AND SCOPE

This Engineering Evaluation/Cost Analysis (EE/CA) was prepared to fulfill the requirements of Section 300.415(b)(4)(i) of the National Contingency Plan (NCP) for the proposed non-time critical removal actions (RAs) at the former Laboratory for Energy-Related Health Research (LEHR, Site) located at the University of California, Davis (UC Davis) (Figure 1-1).

Figure 1-2 shows the U.S. Department of Energy (DOE) areas of responsibility. A Memorandum of Agreement (MOA) (DOE, 1997) between DOE and UC Davis allocates Site environmental restoration responsibilities between DOE and UC Davis (Table 1-1). According to the MOA, DOE is responsible for environmental restoration of the following areas:

- Southwest Trenches;
- DOE Disposal Box;
- Radium/Strontium (Ra/Sr) Treatment Systems;
- Dog Pens; and,
- Domestic Septic Systems.

The Southwest Trenches, the Ra/Sr Treatment Systems and the Domestic Septic Systems areas were addressed in an EE/CA prepared in January 1998 (Weiss, 1998a). The DOE areas addressed in this EE/CA are:

- Western Dog Pens (WDPs) and,
- Eastern Dog Pens (EDPs).

The DOE Disposal Box was addressed as a time-critical RA in 1996. The 1998 EE/CA listed the Northern Chemical Dispensing Station as one of the DOE areas. However, it was removed from the list of DOE areas known or suspected to be contaminated in a Federal Facility Agreement signed by the DOE, the U.S. Environmental Protection Agency (EPA) and the Central Valley Regional Water Quality Control Board (CVRWQCB) in 1999.

1.1 Objectives and Scope

The primary objective of this EE/CA is to develop suitable RA alternatives for the environmental restoration of the remaining DOE areas not addressed by the January 20, 1998 EE/CA. These areas are the WDPs, including the areas adjacent to the Cellular Biology Laboratory, and the EDPs (Figure 1-2).

Documents used to prepare this EE/CA include the *Final Site Characterization Summary Report* (Weiss, 1997f), the *Draft Final Determination of Risk-Based Action Standards* (Weiss,

1997d) and the *Draft Final One-Dimensional Vadose Zone Modeling Report* (Weiss, 1997b). This EE/CA uses information from the following reports specific to the Dog Pens: *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (Weiss, 1999c); *Final Technical Report: Results of Western Dog Pens, Background, and Off-Site Investigations* (Weiss, 1998c); and *Draft Technical Memorandum: Statistical Comparison of Western Dog Pens Soil Data with Risk-Based Target Levels* (Weiss, 1999b). Information from these reports was used to evaluate and select RAs presented in this EE/CA in accordance with guidance from the EPA. The data were used in these evaluations to: 1) assess the nature and extent of the environmental impact associated with the Dog Pens operations; 2) evaluate potential contaminant migration pathways; 3) assess the actual and potential risks posed by the contaminants to human health and the environment; 4) compare alternatives for the WDPs and EDPs based on technical, economic and environmental considerations; and 5) select a preferred RA alternative for the WDPs and EDPs.

The goals of this EE/CA are to:

- Establish removal action objectives (RAOs) defining the environmental restoration goals for the proposed RAs;
- Develop, evaluate and compare alternatives capable of meeting these RAOs;
- Evaluate the potential environmental effects of conducting the proposed RA; and,
- Select RAs for the WDPs and EDPs.

1.2 Report Organization

The organization and content of this EE/CA is based on "Guidance on Conducting Non-Time-Critical Removal Actions Under Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980" (EPA, 1993). This EE/CA also addresses the requirements of the National Environmental Policy Act (NEPA). An Environmental Assessment (EA) developed in conformance with the DOE guidance "Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements" (DOE, 1993a) and DOE Order 451.1A is presented in Section 8 of this report.

This report consists of nine sections, including this Introduction (Section 1). Section 2 briefly describes the Site history and environmental setting. Section 3 presents a synopsis of the source, nature and extent of contamination including a description of previous site investigations. Section 4 identifies RA objectives including legal requirements and Risk-Based Action Standards (RBASs). Section 5 develops RA alternatives and evaluates each alternative based on cost, effectiveness and implementability. Section 6 compares the RA alternatives developed in Section 5. Section 7 selects preferred RAs for the WDPs and EDPs. Section 8 provides an environmental assessment for the preferred RAs and alternatives. Section 9 is a list of references cited. The document also contains appendices, which provide additional details.

Table 1-1. DOE Areas of Responsibility

	Description	Reference	Comments
Southwest Trenches	Disposal trenches and chemical dispensing area in the southwest corner of the Site	Draft Final Work Plan for Removal Actions in the Southwest Trenches, Ra/Sr Treatment System Areas, and the Domestic Septic Systems, Rev. F (Draft Final Work Plan)	RA completed in 1998.
DOE Disposal Box	Subsurface disposal area defined by metal matting located between the two sets of dog pens		Part of time-critical RA completed by DOE in 1996.
Radium Treatment System	Ra-226 treatment tank and the associated leach field and dry wells	Draft Final Work Plan	RA completed in 1999.
Strontium Treatment System	Sr-90 treatment tanks and associated leach system	Draft Final Work Plan	RA scheduled for 2001.
Dog Pens Area, Western	WDPs including the southern portion of the area currently occupied by the Cellular Biology Lab	Addressed in this EE/CA.	Addressed in this EE/CA.
Dog Pens Area, Eastern	EDPs	Addressed in this EE/CA.	Addressed in this EE/CA.
Domestic Septic Systems	Seven abandoned domestic septic systems at LEHR	Draft Final Work Plan	RA scheduled for 2001.

Abbreviations:
DOE U.S. Department of Energy
EDPs Eastern Dog Pens
EE/CA Engineering Evaluation/Cost Analysis
LEHR Laboratory for Energy-Related Health Research
RA Removal Action
Ra-226 Radium-226
Sr-90 Strontium-90
Ra/Sr Radium/Strontium
WDPs Western Dog Pens

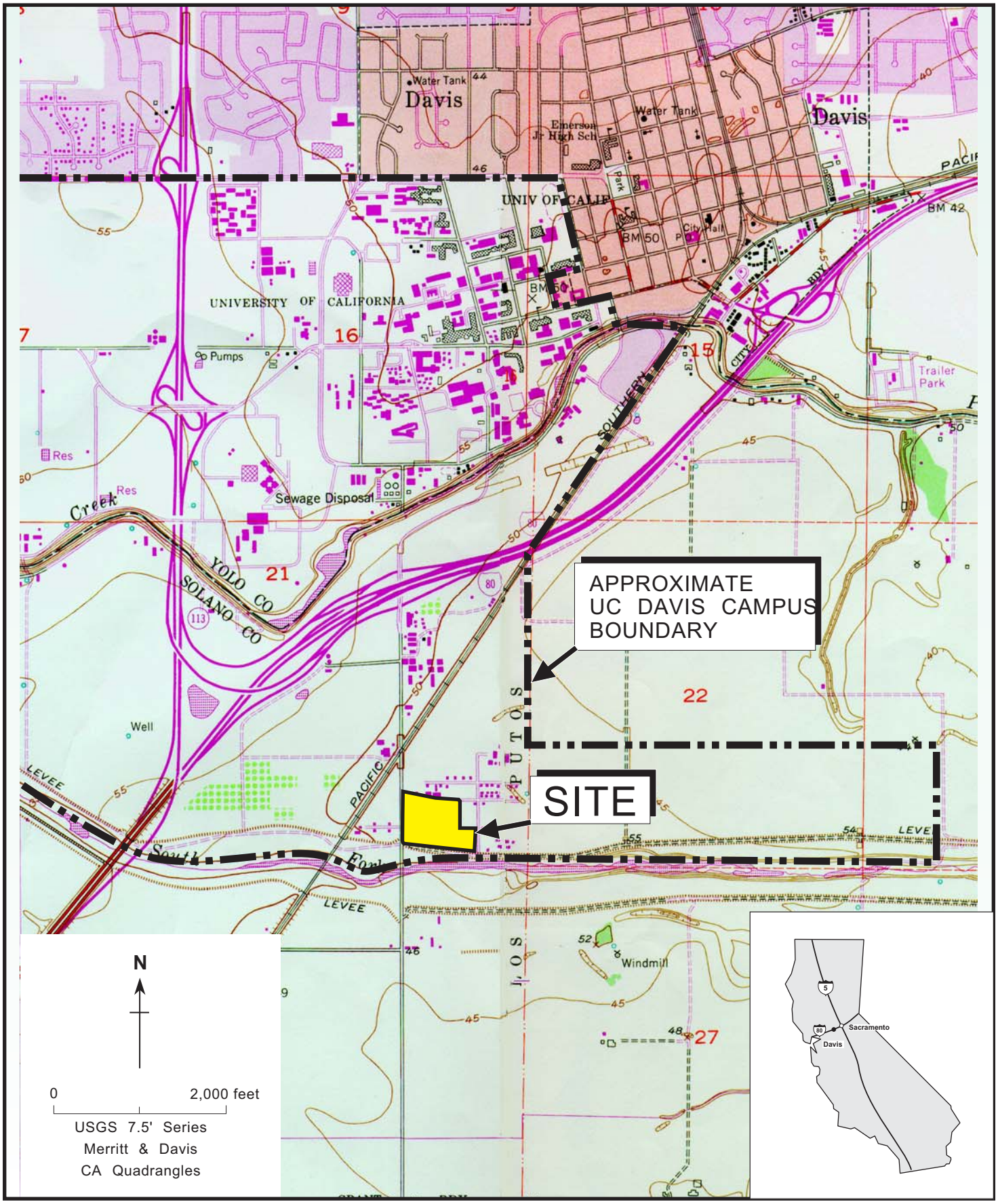

Figure 1-1. Laboratory for Energy-Related Health Research Location Map, UC Davis

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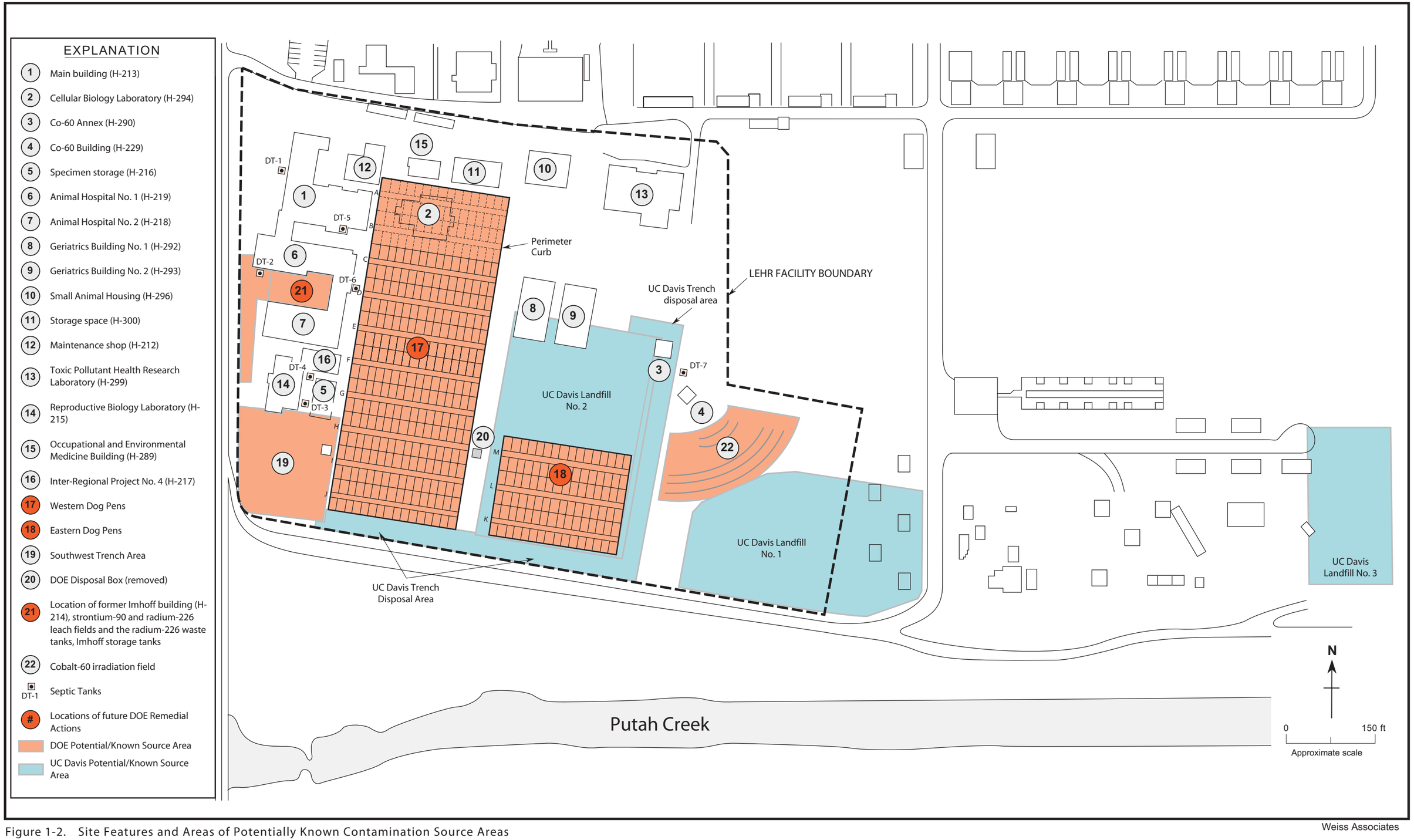


Figure 1-2. Site Features and Areas of Potentially Known Contamination Source Areas

Weiss Associates

2. BACKGROUND AND ENVIRONMENTAL SETTING

2.1 Site Background

The Site background is summarized in Sections 2.1.1 through 2.1.6.

2.1.1 Location

The Site is located immediately east of Old Davis Road, just south of U.S. Interstate Highway 80 (I-80) in Solano County, California, in the southeast quarter of Section 21, Township 8 North, Range 2 East, Mount Diablo Base and Meridian (Figure 1-1). It is approximately 1.5 miles south of the town of Davis, in the southeast portion of the UC Davis campus.

2.1.2 History of Operations

The Atomic Energy Commission (now DOE) began conducting radiological studies on laboratory animals, particularly beagles, in the early 1950s. Initial studies were carried out on the main campus and involved the irradiation of beagles. The Site began operating in its present location in 1958 when full-scale experimental use of radioactive materials began. Research at LEHR through the mid-1980s focused on the health effects from chronic exposure to radionuclides, primarily strontium-90 (Sr-90) and radium-226 (Ra-226). In the early 1970s, a cobalt-60 (Co-60) irradiator facility was constructed at the Site to study the effects of chronic exposure to gamma rays on bone marrow cells of beagles. The UC Davis Institute of Toxicology and Environmental Health (ITEH) presently occupies the Site.

Following an indoor holding period, the irradiated beagles were moved outside to the Dog Pens. From available architectural drawings and Site documents, the following construction timeline was developed. By June 1958, 64 outside pens (Rows A and B, Figure 1-2) were completed, with the exception of dog house installation and surfacing with crushed rock. These outside pens were scheduled to be completed and occupied by September 1958 (Second Quarterly Progress Report, June 1958). By 1960, 96 outdoor pens (Rows A through C) were completed and put into operation (Fifth Annual Progress Report). By February 3, 1961, 128 pens (Rows A through D) were complete. Based on site investigations, these original four rows, A through D, contain sub-grade gravel-filled trenches that are oriented east-west. Construction drawings indicate that these trenches contain a water line. Otherwise the design purpose of these trenches is not known. Between 1961 and 1964 an additional 64 pens were constructed (Rows E and F) for a total number of 192 pens. Between 1964

and 1968, the remaining 128 WDPs were constructed (Rows G through J). In rows E through J of the WDPs, the water lines were not buried in gravel trenches. In 1975, 64 pens (Rows A and B) were removed during construction of the Cellular Biology Laboratory. The gravel and interior curbing were removed, but the perimeter curbing was left in place. According to aerial photographs, Rows K and L of the EDPs (Figure 1-2) were constructed by May 1968. The final row of the EDPs (Row M) was completed by March 1970. Water lines in the EDPs were not bedded in gravel.

From the 1940s through the mid-1960s, portions of the Site were used as the UC Davis campus landfill. UC Davis landfills were operated at the Site until 1967. Landfill Disposal Unit 1 was used from the 1940s through the late 1950s or early 1960s. Landfill Disposal Unit 2 was used from 1956 through 1967. Part of Landfill Disposal Unit 2 underlies the EDPs (Figure 1-2). A third UC Davis Landfill, Disposal Unit 3, is located approximately 600 feet (ft) east of the Site and was used from 1963 to the 1970s. Burial holes and trenches around the landfills were used to dispose low-level radioactive and mixed waste from UC Davis and LEHR research activities. Figure 1-2 shows the locations of the three UC Davis landfills and other waste disposal areas. The Site was placed on the EPA's National Priority List (NPL) in May 1994.

2.1.3 Present Facility Use

DOE has no present or planned future activities at the Site aside from environmental restoration and waste management activities. Site improvements originally completed by DOE will be transferred to UC Davis upon completion of necessary environmental restoration associated with those structures as described in the MOA between DOE and UC Davis.

UC Davis is currently using the Site for research activities and is likely to continue these activities in the foreseeable future. ITEH occupies several former LEHR facilities. ITEH activities involve approximately 200 University researchers and support staff. ITEH researchers and student assistants have varying schedules and are not present at the Site at the same time.

Various ongoing DOE environmental restoration activities at the Site involve contractor staff and subcontractors. The total number of full-time Site workers employed in these activities is currently five, but this number can temporarily increase to approximately 20 to 25 during full-scale RAs. These RAs are likely to continue through the year 2003.

2.1.4 Physical Setting

The land within a one-mile radius of the Site is owned both privately and by the Regents of the University of California, and is used for animal research, agriculture and recreation. Immediately east, north and west of the Site are UC Davis-owned research facilities. Privately owned lands within one mile to the south and east of the Site include permanent residences and fields that support some crops. Approximately 75% of the surrounding land in the general vicinity of the Site is used for agriculture. Major crops include fruits, nuts and grains. Approximately 40% of the agricultural

land in the LEHR vicinity is irrigated and some of the nearby lands are used for cattle grazing (DOE, 1988). Recreational uses in this area primarily involve fishing and swimming along nearby Putah Creek.

2.1.5 Structures and Topography

The Site occupies approximately 15 acres and is located in a rural area in the Sacramento Valley. The property contains mainly single-story laboratory buildings and former animal-handling facilities. Figure 1-2 shows the locations of the buildings at the Site. Approximately 40% of the 15 acres is paved or covered by structures. Approximately 30% is unpaved and relatively free of vegetation. Approximately 5% is covered by large, deep-rooted vegetation. The outdoor Dog Pens occupy approximately 20% of the Site, or 3 acres.

The Site is situated on gently sloping land, with an average elevation of approximately 50 ft above mean sea level. The land surface slopes to the east/northeast at approximately 0.001 ft/ft (5 ft per mile). Relief across the Site is about 2 ft.

2.1.5.1 Sanitary Sewer Systems

The Site currently discharges sanitary wastewater to the UC Davis Wastewater Treatment Plant located approximately one mile north of the Site. UC Davis operates the plant under the conditions specified in its National Pollutant Discharge Elimination System permit, granted by the CVRWQCB under authority from the EPA. All seven Domestic Septic Systems and leach fields associated with DOE operations have been abandoned and replaced by direct connections between the Site buildings and the sanitary sewer.

2.1.5.2 Stormwater Collection System

As shown in Figure 2-1, stormwater runoff at the Site is collected in surface and sub-surface drainage systems. Stormwater from the paved area in the western part of the Site is collected in catch-basins and discharged to an unlined ditch along Old Davis Road. Drainage around the southern buildings in the western area is collected in a main stormwater drainage system, routed to the Site stormwater lift station and subsequently pumped to an outfall along the east side of Old Davis Road, where it is discharged to an unlined ditch. Stormwater flows to the west side of Old Davis Road in a culvert pipe and then flows south to Putah Creek in an unlined ditch. Stormwater that falls along the eastern and non-paved southern portions of the Site, including most of the Southwest Trenches and the EDPs and WDPs, infiltrates into the soil. Drainage for a section of the former Co-60 field where dog pens were once located is connected to the sanitary sewer. Water ponds during heavy rains in some areas on the Site, including the EDPs and WDPs.

2.1.6 Geology/Hydrogeology

2.1.6.1 Local Geology

The Site and vicinity are in the Putah Plain of the Sacramento Valley (DWR, 1978), which consists of alluvial fan deposits associated with Putah Creek. These alluvial sediments consist primarily of silt and clay with localized, interfingered, coarse-grained sediments and are approximately 180 ft thick (DWR, 1978). Beneath the Site, the sediments are nearly flat-lying and conformably overlie the Tehama Formation, the principal water-bearing geologic unit on the west side of the Sacramento Valley.

The depths and types of major sedimentary units encountered in boreholes beneath the Site are described below from youngest to oldest. Some of the units contain gradational sequences or more than one lithology.

- 0 to 80 ft—Interbedded silt, clay and sand with some sand and gravel channel deposits. The surficial soils are underlain by interbedded clay, silty clay, silt and sand. This fine-grained interval is fairly continuous across the Site and contains some coarse sand and gravel. The ground water table is in this stratigraphic unit and varies in depth from approximately 2 to 65 ft below ground surface (bgs), depending on the season and total rainfall.
- 80 to 135 ft—Cobbles and gravel. Well-rounded cobbles and gravel are encountered at approximately 80 ft bgs and appear to be laterally continuous beneath most of the Site. Where present, this unit is approximately 35 to 52 ft thick.
- 135 to 143 ft—Clay and some silt. Clay and silt underlie the cobbles and gravel. The top of this clayey unit is encountered at depths ranging from 120 to 137 ft bgs (Dames & Moore, 1993).

2.1.6.2 Surface Soil

The surface soils at the Site have been mapped as Reiff fine sandy loam in the Soil Survey of Solano County, California (USDA, 1977). These soils are relatively young and weakly developed. The "A" horizons are relatively thick and organic-rich, and therefore ideal for agriculture (USDA, 1977). Surface soils have been disturbed in some areas of the Site including the EDPs and former Rows A and B of the WDPs, as a result of subsurface disposal and construction activities.

2.1.6.3 Hydrogeology

Unconsolidated Pliocene and Pleistocene deposits are the major ground water sources for public and private water supplies in the Sacramento Valley (DWR, 1978). Both unconfined and confined fresh water aquifers are present in these sedimentary deposits in the uppermost 3,000 ft of the valley subsurface. Ground water generally flows from the valley sides towards the valley axis. In the vicinity of the Site, regional ground water generally flows east from the Coast Ranges toward the Sacramento River (Dames & Moore, 1993).

At various depths beneath the valley floor, fresh water gives way to saline water as a result of entrapment during the deposition of sediments in a marine environment. The depth to the base of fresh water in the Sacramento Valley varies from 400 ft to over 3,000 ft, and is 2,600 to 3,100 ft bgs in the Davis area (Division of Oil & Gas, 1982).

The results of previous investigations identified five hydrostatigraphic units (HSUs) beneath the Site (Dames & Moore, 1999). The HSUs identified beneath the Site include the vadose zone, HSU-1, HSU-2, HSU-3 and HSU-4. The vadose zone extends from the ground surface to the top of ground water, which has historically ranged from 15 to 55 ft bgs. The vadose zone consists primarily of unsaturated clay and silt with lesser amounts of interbedded sand and gravel. HSU-1 extends from the bottom of the vadose zone to a depth of approximately 76 to 88 ft bgs. This unit is lithologically similar to the vadose zone and consisted primarily of silt and clay, with lesser amounts of sand and gravel. HSU-2 extends from the bottom of HSU-1 to a depth of approximately 114 to 130 ft bgs. This unit is composed primarily of sand in the upper portion of the unit and gravel in the middle to lower portions of the unit. HSU-3, investigated in off-site areas, extends from the bottom of HSU-2 to a depth of about 250 ft bgs and is approximately 120 ft thick. The unit consists primarily of relatively fine-grained sediments varying from very fine-grained sandy silt to clayey silt and silty clay. HSU-4, investigated in off-site areas, extends from the bottom of HSU-3 to a depth of about 282 ft bgs and is approximately 32 ft thick. This unit consists of coarse sand and gravel. Beneath HSU-4, a sharp contact with a bluish, dark gray silt was encountered at 282 ft bgs in wells UCD4-41 and UCD4-43. The bottom of this unit was not penetrated in any of the Site borings (Dames & Moore, 1999).

The uppermost distinct aquifer beneath the Site has been divided into two HSUs (HSU-1 and HSU-2), based on the stratigraphy of the sediments at the Site and the associated ground water flow and contaminant migration characteristics (Dames & Moore, 1994d). Well drillers' logs indicate that a 90-ft-thick clay unit separates HSU-2 from a second aquifer below (Dames & Moore, 1994a).

Irrigation water, rainfall and Putah Creek recharge ground water in the vicinity of the Site (Dames and Moore, 1997). The main component of ground water recharge, however, has been identified as irrigation water infiltration (WA, 1998d). Ground water pumping associated with agricultural demands is largely responsible for ground water withdrawal. In addition, UC Davis extracts ground water from HSU-2 as part of its interim remedial actions.

Generally, there is a 20- to 30-ft seasonal fluctuation in the depth-to-ground water beneath the Site caused predominantly by the lack of surface recharge and agricultural pumping in the summer. Vertical gradients vary both temporally and spatially. The magnitude of the vertical gradient is greatest when ground water elevations are rising or falling sharply. Short-term activities such as local agricultural pumping can produce downward vertical gradients during periods of an otherwise rising water table.

The HSU-1 lateral gradient across the Site typically ranges from 0.01 to 0.04 ft/ft, and the direction of ground water flow is predominantly northeast. Representative values of HSU-1 horizontal hydraulic conductivity are between 1×10^{-4} and 1×10^{-7} centimeters per second (cm/sec) (Dames & Moore, 1999). The lateral gradient across the Site within HSU-2 typically ranges from

0.005 ft/ft to 0.015 ft/ft. The direction of flow appears to be predominantly northeast although it can occasionally be east-southeast. Based on pumping tests, hydraulic conductivity in HSU-2 ranges from 0.26 to 0.43 cm/sec (Dames & Moore 1997a).

Ground water in HSU-1, HSU-2 and HSU-4 has been impacted by Site activities. Based on investigations to date (Weiss, 1997e; Weiss, 1999c), significant ground water impact appears to be associated only with the UC Davis disposal areas.

2.1.6.4 Surface Water

The east-flowing South Fork of Putah Creek borders the southern portion of the Site and is separated (from the Site) by the north levee of the creek. In 1948, the U.S. Army Corps of Engineers (USACE) modified the South Fork and dammed the North Fork so that all water in Putah Creek now flows in the South Fork. Putah Creek is a "losing" stream (water flows from the streambed toward the ground water table) in the LEHR vicinity; therefore, Putah Creek water may impact shallow ground water beneath the Site, but not vice-versa.

Flow in the South Fork of Putah Creek is regulated by releases from Monticello Dam at Lake Berryessa and from the Putah Diversion Dam, located about 18 and 14 miles west of the Site, respectively. Based on data from 1980 through 1991, flows several miles upstream from the Site typically range from 0.1 cubic feet per second (cfs) to about 3 cfs, although flows as high as 15,500 cfs (in March 1983) have been reported (Dames & Moore, 1994a). In the reach bordering the Site, flow in the South Fork of Putah Creek is supplemented by discharge from the UC Davis Wastewater Treatment Plant (Figure 1-1). Based on data from a gauge near Old Davis Road, flow rates for the reach bordering the Site ranged from 0.17 to 148 cfs from 1989 to 1993. Flows have not changed substantially since 1993 (Weiss, 1997f).

2.2 Existing Environmental Setting

The environmental setting sections are necessary to assess impacts as required under NEPA and DOE statutes. They describe conditions of the existing Site and some surroundings including:

- Water resources;
- Ambient air quality;
- Ambient noise quality;
- Aesthetics and scenic values;
- Biological resources (plants and wildlife);
- Flood plains;
- Socioeconomic conditions;
- Historical and cultural resources;
- Land use; and,
- Human health issues.

2.2.1 Water Resources

This section describes the water resources at the Site and, where appropriate, the adjacent area. Water resources include ground water and surface and recreational waters (i.e., rivers and wetlands).

2.2.1.1 Ground Water

The occurrence and characteristics of ground water beneath the Site have been summarized in numerous reports (Weiss, 1997f; Dames & Moore 1999; PNNL, 1996). Hydrogeologic characteristics of the Site are described in Section 2.1.6.3. Ground water quality is summarized here based on detailed information reported in *Final Tiered Initial Study, Laboratory for Energy-related Health Research and South Campus Disposal Site Interim Remedial Actions Project* (UC Davis, 1997).

There are a total of 40 monitoring wells on and around the Site that monitor HSU-1, HSU-2 and/or HSU-4 ground water wells. Ground water samples from these wells and Hydropunch locations provide information on ground water characteristics and quality. Ground water wells are also present in the surrounding areas and are used to provide water for agricultural and domestic purposes. Site ground water is not currently used for drinking water or other direct human use, nor is it expected to be used in the future. Drinking water is supplied by the campus water system, which is supplied by five deep wells, the nearest of which is about 400 ft north of the Site.

Regional water quality has been impacted by the presence of nitrates due to agricultural sources, and hexavalent chromium (Cr-VI), probably from natural sources (Dames & Moore, 1997). Ground water in HSUs 1 and 2 has been impacted by past Site activities.

As indicated in Section 1, DOE and UC Davis have signed a MOA to divide responsibility for Site areas of contamination according to historical information regarding use and operation. UC Davis has assumed responsibility for ground water remediation activities. The primary constituents of concern in ground water are chloroform and other volatile organic compounds (VOCs), chromium (primarily as Cr-VI) and nitrate. UC Davis is currently operating an interim remedial action system to extract and treat chloroform in HSU-2 and gather data that will aid in the assessment of ground water treatment effectiveness and the need for further ground water remedial actions. Approximately 41 pounds of chloroform have been removed from HSU-2 since the system began operation in 1998 (Dames & Moore, 1999).

2.2.1.2 Surface and Recreational Waters

No natural or man-made surface or recreational waters are present at the Site. The South Fork of Putah Creek is about 125 ft south of the Site within a man-made channel; the channel is separated from the boundaries of the Site by a two-lane paved roadway on top of the levee. Unrelated to Site activities, the South Fork of Putah Creek was redirected within a man-made channel to divert floodwaters from the City of Davis and the UC Davis main campus. It is an intermittent stream, sometimes containing only scattered pools during the dry summer months. In the past, drought conditions have resulted in the lower portions going dry and in significant fish and

invertebrate animal kills (Marchetti and Moyle, 1995). The creek is typically bordered by dense vegetation and small trees within and adjacent to the channel.

The South Fork of Putah Creek in the vicinity of the Site is used for recreational activities such as fishing, swimming, rafting and other related water activities. In addition, the creek and channel with its dense vegetation and trees constitute an open space area that provides habitat for birds and small wildlife.

The South Fork of Putah Creek is identified as wetlands by USACE. Wetlands perform vital ecological functions and are important to the public interest. They provide communities with a variety of resident and migratory animal species habitat, breeding, spawning and forage areas. Wetlands also provide for the movement of water and sediments, ground water recharge, water purification, storage of stormwater runoff and recreation.

Direct sampling of surface water in Putah Creek is conducted by UC Davis as part of its CERCLA responsibilities. Surface water samples are collected from two sampling points in Putah Creek—one located upstream from the Site and one located downstream. Water samples are also collected at the UC Davis wastewater treatment plant outfall. These data, while valuable, do not allow full evaluation of the impact from DOE Areas on Putah Creek surface water since they reflect in-stream contaminant levels that may have many sources other than the DOE areas.

Stormwater sampling data could potentially be considered direct measurements of potential DOE-related impacts to Putah Creek. Stormwater sample data for DOE areas are from sampling point Lift Station (LS)-1, which is on the west side of the Site that discharges to Putah Creek (Figure 2-1). Stormwater from the primarily paved portion of the Site, including the eastern side of the Animal Hospital Buildings and the area near the WDPs is then routed to the LS-1. A portion of the Ra/Sr Treatment System and Septic Tanks areas also drains to Putah Creek via the lift station at LS-1 or by direct drainage into the unlined ditch along Old Davis Road. Stormwater runoff from the remainder of the DOE areas, including a small portion of the Ra/Sr Treatment System Area, WDPs and EDPs, DOE Southwest Trenches Area and Disposal Box, ponds and infiltrates into Site soil or evaporates.

Two additional stormwater monitoring points, Landfill (LF)-1 and LF-3, are monitored by UC Davis in UC Landfill Disposal Units 1 and 3, respectively. In these areas, stormwater collects or infiltrates into the soil, is directed to the sanitary sewer, or is discharged to Putah Creek via culverts and a drainage ditch. These monitoring points are not located in DOE areas.

2.2.2 *Ambient Air Quality*

The Site is located within the Yolo/Solano Air Quality Management District and is part of the Sacramento Valley Air Basin. The Site is located in a state and federal non-attainment area for particulate matter with less than 10 microns aerodynamic diameter (PM_{10}) and ozone.

The prevailing wind direction at the Site is from the south, reflecting frequent incursions of marine air through the Carquinez Strait into the Sacramento Valley. Changes in wind direction are common, with winds from the northwest occurring diurnally. During the summer months (May through September) the predominant wind direction is from the south. The average windspeed recorded at the Site meteorological station in 1999 was approximately 1.14 meters per second (2.49 miles per hour).

Within the Site and surrounding areas, the most notable sources of air pollution are from moving automobiles (primarily from Old Davis Road, the Site, adjacent roads and freeways). Fugitive dust (i.e., particulate matter) is associated with moving vehicles, construction equipment (when construction or earth-moving activities occur) and agricultural equipment (when work such as harvesting, planting and clearing is involved). Fugitive dust is also generated when high winds blow over dry, barren or open fields.

Airborne radionuclides are sampled by a network of four air samplers: three on the Site perimeter and one at a distant location. Perimeter samplers are located around the Site, in the prevailing downwind directions to the north and south of the Site. The distant air sampling location is approximately six miles (ten kilometers) northwest of the Site and provides background data from an area essentially unaffected by Site operations.

The analytical results of a one-year baseline air sampling investigation were presented in Pacific Northwest National Laboratory's (PNNL's) Baseline Air Monitoring Report (PNNL, 1996). Both the average and maximum activities of total alpha and total beta radiation collected during the baseline air sampling investigation were similar for Site perimeter locations and the distant location, indicating that the observed levels were predominantly the result of natural sources and worldwide fallout. Air monitoring data confirm that detectable levels of gamma-emitting radionuclides at the Site are in compliance with 40 CFR Part 61 Subpart H requirements, and that small detectable levels are likely associated with background sources (PNNL, 1996). All measured activities for isotopic thorium, uranium, radium and strontium collected during the one-year baseline air sampling investigation were also well below the DOE Derived Concentration Guide (DCG) (DOE, 1990).

The analytical results for samples analyzed for non-radiological pollutants are also presented in detail in PNNL's Baseline Air Monitoring Report (PNNL, 1996). In general, detectable concentrations of metals were found in ambient air at both the Site and distant stations. Alpha-chlordane, gamma-chlordane, heptachlor and trans-nonachlor were detected in most samples. Cis-nonachlor and heptachlor epoxide were only occasionally detected. Average pesticide air concentrations at on-site stations were similar to the distant station, with no statistical differences compared to the distant station. The air concentrations for the majority of VOCs were below the detection limits. Toluene, dichlorodifluoromethane (Freon-12), trichloroethane and chlorobenzene were detected with low frequencies and concentrations at the Site. Freon-12 and toluene were also detected at the distant station.

All ambient air samples collected during the 1998 Southwest Trenches RA and the 1999 Ra/Sr Treatment System Area I RA contained radionuclide concentrations below their specific background values or below the DCG. PM_{10} concentrations during both RAs never exceeded the 150 micrograms per cubic meter air quality standard.

The current air monitoring program includes:

- Outdoor ambient air monitoring at the three on-site and one background locations once prior to each RA to obtain baseline data; analyses include alpha/beta, gamma, semi-volatile organic compounds (SVOCs), chlordane and PM_{10}/inorganics;
- Outdoor ambient air monitoring once a month during each RA; analyses include alpha/beta and PM_{10}/inorganics; and,
- Outdoor ambient air monitoring once at the end of each RA; analyses include alpha/beta, gamma, SVOCs, chlordane and PM_{10}/inorganics; these data are compared to baseline data.

2.2.3 Ambient Noise Quality

No significant or loud noises appear to affect the Site although several sources of noise exist, including vehicular traffic, sounds from air conditioning units and other operating equipment (such as monitoring equipment on the Site), moving railroad trains and cars (located about 0.25 mile from the Site) and small aircraft. Ambient noise level surveys were not conducted as a part of this analysis.

2.2.4 Aesthetics and Scenic Values

The Site is primarily covered with buildings, pavement, the Dog Pens and relatively small (less than one acre) open or grassy areas, with trees and scattered strips of landscaping alongside buildings. The boundaries of the Site are demarcated by chain link fences. Mature pine are located along portions of the south and north boundaries of the Site. Although aesthetics and scenic values are subjective, the present Site appearance is not found to have high scenic value.

Surrounding farmlands contain open space and contrast with the Site's synthetic structures and anthropogenic modifications. Visually, these farmlands generally provide a sense of wide expanse and greenery, which lends scenic and visual value to the area.

Putah Creek, south of the Site, is another area of scenic and visual value because of its flowing water. In addition, the diversity of vegetation and wildlife alongside the creek add to the scenic appeal of Putah Creek.

2.2.5 Biological Resources

The biological resources discussed here are plant communities and wildlife. Detailed information on the plant communities and wildlife has been gathered to develop an Ecological Scoping Assessment that is contained in the *Draft Final Ecological Scoping Assessment for DOE*

Areas for the U.S. Department of Energy Areas at the Laboratory for Energy-related Health Research, University of California at Davis, California (Weiss, 1997a). The subsections below summarize the information regarding existing Site plants and wildlife. All plant and animal species known or expected to occur on-site or nearby are listed in Tables B-1 and B-2, respectively, in Appendix B.

As shown on federal flood maps, the 100-year flood plain is confined within the Putah Creek levees at the southern boundary of the Site. The Site lies in the Federal Emergency Management Administration (FEMA) Zone C. The area is expected to experience minimal flooding.

2.2.5.1 Plant Communities

Areas of the Site not covered by buildings, structures and pavement support ruderal vegetation (e.g., weeds), non-native grassland, landscaping (primarily horticultural trees) and bare ground. Habitats include ruderal/non-native grassland, buildings and structures and ruderal/landscaped ornamental trees. The locations within the Site that do not fall within one of these three habitats are few and sparse but may be foraged. No naturally occurring special-status communities occur at or immediately adjacent to the Site (including the south fork of Putah Creek and the channel it lies within).

Special-status species are those species of plants and animals defined under the Endangered Species Act (50 CFR 17.12), California Endangered Species Act (14 CCR 670.5) and those considered sufficiently rare by the scientific community to qualify for such a listing. No special-status species of plants were detected or have been recorded at the Site or the surrounding region (within approximately a one-mile radius from the Site).

2.2.5.2 Wildlife

A variety of animal species have been observed on the Site and the adjacent areas. Although many of these animal species are not likely to live within the Site, they may forage there. Resident burrowing mammals observed at the Site include the California ground squirrel, California vole, Botta's pocket gopher and various mice species. Common predatory mammals and reptiles likely to forage on the Site include the coyote, gray fox, red fox, house cat, gopher snake and garter snake. Common predatory birds likely to forage on the Site include the red-tailed hawk, red-shouldered hawk, American kestrel, great-horned owl and barn owl. Common fish expected in the creek include largemouth bass, green sunfish, carp and catfish. Fish-eating animals likely to occur in the south fork of Putah Creek include river otter, beaver and muskrat.

A total of 7 special-status wildlife species are considered to have a moderate to high potential to inhabit or forage on the Site. A total of 26 special-status wildlife species have been recorded in the vicinity of the Site or are considered to have a moderate to high potential for occurrence in the area. A potential habitat for the Valley Elderberry Longhorn Beetle (Beetle) (*Desmocerus californicus dimorphus*) was identified in both the WDPs and EDPs. The habitat consists of seven elderberry bushes (Figure 8-1).

2.2.6 Socioeconomic Conditions

The Site is presently occupied by ITEH and the DOE Environmental Restoration/Waste Management project. Current Site use is described in Section 2.1.3.

The Site is located in a rural area in northeast Solano County just outside the City of Davis in Yolo County on the South Campus of UC Davis and is considered part of the Davis/UC Davis community. UC Davis has a 3,600-acre campus and research area, has a student population of approximately 22,000, and employs approximately 15,000 full-time faculty and staff. The current population of Davis is approximately 56,000 and the current population of Yolo County is over 158,800. In 1999, the total employment in Yolo County was 86,200; the government (27,500) provided 31.9% of those jobs. The City of Davis has approximately 21,000 housing units. The more densely populated and metropolitan Sacramento area is approximately 13 miles east of the Site. The population of Sacramento County is about 1,177,800, and approximately 396,200 people live in the City of Sacramento. Agricultural employment is a small fraction of total employment and is not considered a major employment source.

2.2.7 Historical and Cultural Resources

The past DOE-sponsored operations of the Site are discussed in Section 2.1.2. Historically, the Site was used for agriculture. Cultural resources are not known to be present within the Site. Given the high disturbance to the surface and subsurface of the Site, it is highly unlikely that cultural resources are there or could be found.

2.2.8 Land Use

As shown on Figure 1-1, land in the vicinity of the Site is either part of the UC Davis campus or in agricultural use. Immediately adjacent to the Site are the UC Davis Raptor Center and animal research facilities. The Raptor Center primarily houses raptors that have been injured or orphaned. Additionally, an unrestricted outdoor area containing a burrowing owl project is also located about 1,500 ft east of the Site. Other UC Davis animal research includes horses, cows, goats and other domesticated farm animals located in outdoor corrals and pens. Agricultural land lies south of Putah Creek and east and west of property owned by UC Davis. Wheat, tomatoes, corn, barley and oats are mainly grown on this agricultural land. The main UC Davis campus and the City of Davis (downtown area) are located 1.2 and 1.9 miles, respectively, north of the Site.

The Site is designated as "Urban and Built-up Land" by the State of California Department of Conservation for Yolo and Solano Counties Important Farmlands Maps (UC Davis, 1997). Specific land uses on the Site and the immediate adjacent areas are under the control of UC Davis and are consistent with the UC Davis long-range development plans (UC Davis, 1997).

Future land use plans for the surrounding areas outside of UC Davis do not identify significant changes with the exception of development of a light industrial area about one mile north of the Site, near I-80 and within the boundaries of the City of Davis. According to UC Davis, long-range planning predicts Site use to remain research-oriented for the foreseeable future.

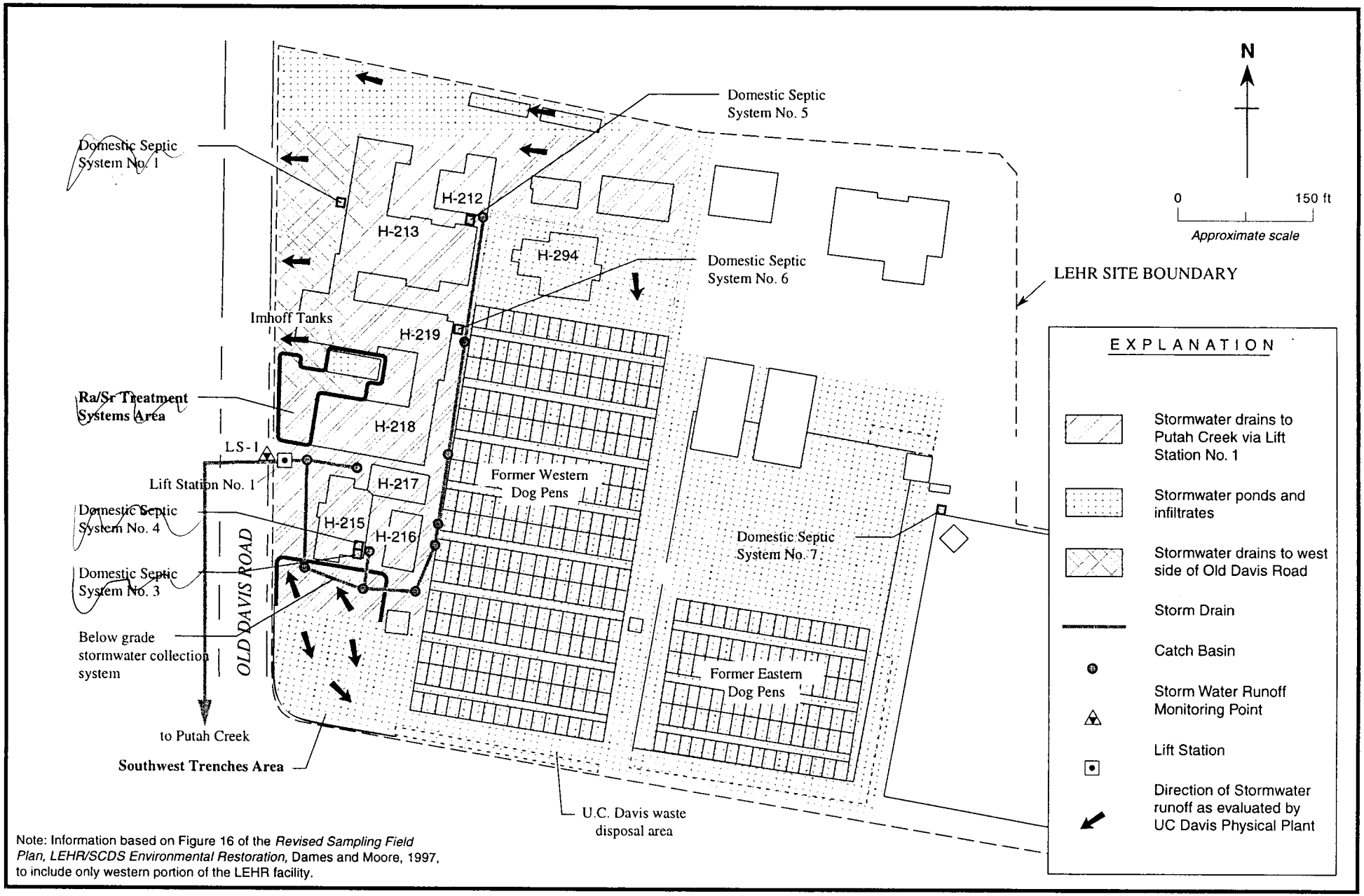
2.2.9 Human Health Considerations

Concerns for human health in the DOE areas are primarily related to radiation exposure from previous activities at the Site. Radiation levels are monitored within and at the perimeter of the Site, and radiation dose estimate calculations are performed and reported annually. As reported in the *Calendar Year 1999 Draft Radionuclide Air Emission Annual Report* (Weiss, 2000b), the maximum individual dose was estimated to be 0.0014 millirem per year (mrem/yr). This is well below National Emission Standards for Hazardous Air Pollutants (NESHAPs) of 10 mrem/yr. The Site complies with 40 CFR Part 61 Subpart H NESHAPs for Emissions of Radionuclides from DOE Facilities. It should be noted that these calculations were based on Site residual surface soil contamination (diffuse sources) for the EDPs and WDPs and the maximum radionuclide concentrations from 1999 waste profile soil sampling or for the Ra/Sr Treatment System Area I RA.

Other issues relating to public health and safety from the standpoint of remediation goals are provided in Section 4.

2.3 Previous and Planned Removal Actions

Over the past eight years, numerous expedited cleanup and source RAs have been successfully completed at the Site. Some of these actions, including decontamination of four buildings, were accomplished prior to EPA adding the Site to the NPL in 1994.Table 1-1 summarizes DOE's previous and planned CERCLA RAs.



Note: Information based on Figure 16 of the *Revised Sampling Field Plan, LEHR/SCDS Environmental Restoration,* Dames and Moore, 1997, to include only western portion of the LEHR facility.

Figure 2-1. LEHR Site Stormwater Runoff Flow Patterns and Collection Systems

Weiss Associates

3. SOURCE, NATURE AND EXTENT OF CONTAMINATION

The source, nature and extent of contamination in the EDPs and WDPs are described in Sections 3.1 through 3.5.

3.1 Potential Sources of Contamination

In 1958, full-scale experimental use of radioactive material began at the Site. Research at LEHR through the mid-1980s focused on the health effects from chronic exposure to radionuclides, primarily Sr-90 and Ra-226. During this period of time, beagles, the primary laboratory test animals, were housed in outdoor areas known as the EDPs and WDPs.

The Dog Pens occupy approximately 20% (3 acres) of the Site. There are currently 256 pens in the WDPs. Sixty-four of the WDPs were removed in 1975 during construction of the Cellular Biology Laboratory. The EDPs consists of three rows of 32 pens, for a total of 96 pens (Figure 1-2).

The radionuclide-dosed dogs were kept indoors for a 30-day holding period, prior to moving to the outside pens (Goldman, 1997; DOE archived records), regardless of the dose level. The dogs placed in the outside pens were paired by sex; two males or two female dogs were placed in each pen (Ballard, 1997; Goldman, 1997; Hinz; 1997). In general, dogs remained in the same pen for the duration of their life span, typically 10 to 12 years (Ballard, 1997; Goldman, 1997; Hinz, 1997). Feces were removed from the pen daily (1958 Annual Progress Report), and urine percolated into the gravel floor of the Dog Pens (Ballard, 1997; Goldman, 1997; Hinz; DOE archived records). The gravel was removed periodically, and possibly disposed off-site (Ballard, 1997) or in the Southwest Trenches (Hinz, 1997).

Calculations made by Rosa, Gielow and Peterson in the 1963 LEHR Annual Report (DOE archived records) indicated that dogs were eliminating up to 0.23 microCuries (μCi) per 48 hours in feces and urine 28 days after Sr-90 exposure. Calculations by Goldman in a 1963 memorandum (DOE archived records) estimated that about 500 microCuries per year (μCi/yr) of Sr-90 and about 50 μCi/yr of Ra-226 were eliminated in urine by the outdoor dogs. Based on the conservative assumptions that: 1) annual elimination at this rate continued for 25 years, 2) all radionuclides in urine migrated through the gravel to the soil, 3) no radioactive decay has occurred and 4) the radionuclides are evenly distributed throughout the first six inches of soil within the Dog Pens (3 acres), this elimination rate translates to maximum soil activities of approximately 6 picoCuries per gram (pCi/g) for Sr-90 and 0.6 pCi/g for Ra-226.

Dogs were dipped in chlordane to control fleas from 1960 until 1968, when excess exposure to chlordane appeared to have impacted the health of the dogs (DOE archived records). The dipping

was apparently performed near the western boundary of the WDPs (Goldman, 1997; Hinz, 1997). It is not clear where the pesticide was stored, whether it was kept in liquid or powder form, or where the dipping fluid was disposed after use. Chlordane was also sprayed in and around the Dog Pens, particularly near the southern edge of the pens because flea-bearing rodents were believed to be more plentiful south of the Dog Pens than in other directions due to the proximity of Putah Creek (Ballard, 1997). Chlordane use continued until the early 1970s with an annual usage estimated to be between 25 and 50 gallons (Dames & Moore, 1993).

3.2 Investigation Design

3.2.1 Western Dog Pens

Four separate investigations of the WDPs have taken place over the last ten years. In 1990, Dames & Moore initiated a Phase II Site Characterization of the LEHR facility (Dames & Moore, 1993). One hundred nine soil samples were collected from the WDPs as part of this site characterization. In 1994, WDPs data was gathered for the *Draft Final Remedial Investigation/Feasibility Study Work Plan* (Dames & Moore, 1994). As part of a limited field investigation in 1996, WDPs concrete fence-post footings (pedestals) were surveyed during their removal and soil beneath selected pedestals was sampled and analyzed. In 1997 and 1998 Weiss Associates performed a three-phase investigation of the WDPs and presented the findings in the *Final Technical Report: Results of Western Dog Pens, Background and Off-Site Investigations* (Weiss Associates, 1998c). In 1999, the EDPs were sampled and the findings were presented in *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (Weiss, 1999c).

The work plans for the 1994 WDPs investigation (Dames & Moore, 1994), 1997/1998 WDPs investigation (Weiss, 1997e and 1998b) and the 1999 EDPs investigation (Weiss, 1999c) were prepared to CERCLA standards and approved by the LEHR Remedial Project Managers (RPMs). All laboratory analyses were performed using the methods specified in the approved work plans. For these reasons, these data sets were used in the statistical evaluation of the Dog Pens' soil. Figure 3-1 shows all 1994 and 1997/1998 WDPs sampling locations. Figure 3-2 shows all the EDPs soil sample locations. Figure 3-3 shows all the EDPs concrete curbing and gravel sample locations.

The 1994 WDPs soil investigation consisted of 17 soil borings, SBL-1 through SBL-16 and SBL-19 (Figure 3-1). Six of these borings (SBL-12 through SBL-16 and SBL-19) were located in the area of previously existing dog pens adjacent to the Cellular Biology Laboratory. This area had not been investigated previously. Most of these borings terminated approximately 2.5 ft bgs, and in some cases approximately 5 ft bgs (Dames & Moore, 1994). These borings were generally evenly distributed to cover the previous dog pens outside of the Cellular Biology Laboratory.

The remaining 11 borings (SBL-1 through SBL-11) were located in areas previously identified as potentially impacted by chemicals or radioactivity in surface soil (Dames & Moore, 1994). Samples were collected at approximately 5 ft bgs in all of these borings. Two of these

borings (SBL-6 and SBL-8), located in areas with the highest nitrate levels reported in previous investigations, were drilled to 20 ft bgs, and additional samples were collected at approximately 10 and 20 ft bgs. Samples from the 1994 WDPs investigation were analyzed for selected metals, organochlorine pesticides, radiologic parameters and general chemical parameters.

The 1997/1998 WDPs investigation followed a three-phased approach, which is discussed in greater detail in the *Final Technical Report: Results of Western Dog Pens, Background and Off-Site Investigations* (Weiss, 1998c). Phase A work consisted of: reviewing available reports and WDPs data collected during prior investigations, interviewing former UC Davis staff who worked at LEHR and conducting a reconnaissance gamma radiation survey over the entire surface of the WDPs. Based on this information, sampling strata were defined based on indications about chlordane and Ra-226 levels in each dog pen. Twelve pens were then selected using a random number generator (RNG) to represent these strata for the Phase B sampling. Phase B was conducted on 12 individual pens to determine if a predictable pattern of elevated constituents of potential concern (COPCs) exists within these selected pens. Phase B field activities consisted of conducting a detailed gamma survey on the gravel surface, collecting gravel samples from each selected pen based on the survey results, removing the gravel from the selected pens and performing a detailed gamma/beta survey on the exposed native soil and collecting surface soil samples. A total of 46 gravel and 75 soil samples, including field duplicates, were analyzed for selected radionuclides, organochlorine pesticide, mercury, Cr-VI and nitrate analyses.

Phase C of the WDPs investigation consisted of collecting soil samples using direct push sampling technology to better define the vertical extent of potential contamination. A total of 20 WDPs were selected for the Phase C investigation. Five of the twenty pens were selected because elevated concentrations of Ra-226 and/or chlordane were detected in them during prior sampling events. The remaining pens were selected at random using a RNG. Soil samples were collected from each boring at 0 and 2 ft bgs, and at three other depths to a total depth of approximately 26 ft bgs. One hundred six soil samples were collected from the WDPs and analyzed for selected radionuclides, organochlorine pesticides, mercury, nitrate and Cr-VI during the Phase C investigation.

3.2.2 Eastern Dog Pens

The EDPs investigation followed a three-phase approach which is discussed in greater detail in the *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (Weiss, 1999c). The three phases were: 1) detailed gamma survey of the entire area, 2) curb and gravel sampling at selected locations, with analysis for Ra-226 and Sr-90 and 3) soil sampling at 0 and 2 ft bgs at selected locations, with analysis for selected radionuclides, metals, nitrogen compounds and pesticides.

In the EDPs, six curb samples were collected from areas with elevated gamma/beta and/or alpha readings and three were collected from areas with background readings. The purpose of the curb sampling was to determine if: 1) the two radionuclides known to have been used in the Dog Pens have impacted the curbs and 2) field gamma readings can be used as an indicator of elevated gamma/beta emitters in the curb. The gravel samples were collected from the 16 soil sampling

locations where gravel was present, and a duplicate gravel sample was collected from one of the locations. Concrete curb and gravel samples collected from the EDPs area were analyzed for Ra-226 and Sr-90.

EDPs soil sampling locations were chosen using a RNG. Nineteen pens were chosen randomly, five of which were designated as "contingency pens". Based on field conditions, pens with elevated gamma survey readings replaced three of the five contingency pens. Each pen was divided into three areas. One of the three areas within the 21 chosen pens was randomly selected for sampling. The EDPs sampling was limited to shallow soil to minimize the risk of intercepting any underlying landfill waste.

3.3 Nature and Extent of Contamination

3.3.1 Soil

3.3.1.1 Western Dog Pens

As described above, the nature and extent of contamination in the WDPs soil is based primarily on the WDPs data gathered for the *Draft Final Remedial Investigation/ Feasibility Study Work Plan* (Dames & Moore, 1994) and the *Final Technical Report: Results of Western Dog Pens, Background and Off-Site Investigations* (Weiss, 1998c). Some qualitative consideration was given to the 109 soil samples collected from the WDPs in 1990 and the 1996 pedestal surveys.

The 1994 and 1997/1998 samples were collected from 45 of the 320 WDPs (approximately 14%). Of these pens, 34 were sampled at multiple depths to determine vertical contaminant distribution, 37 were sampled for surface soil in at least one location and 12 were sampled for surface soil in multiple locations to determine lateral contamination distribution. Approximately half of these WDPs sampling locations were chosen at random and approximately half focused on the areas that had elevated COPCs concentrations in prior sampling events. Therefore the WDPs sampling was very conservatively biased. Table 3-1 summarizes the number of samples analyzed for each COPC suite from each depth interval. Several 1994 soil samples were also analyzed for volatile and semi-volatile organic compounds (VOCs and SVOCs); however, these COPC suites were not included in subsequent investigations based on the lack of detectable concentrations in these 1994 and previous soil samples, and based on the operational history in the area.

Radionuclides and metals detected above background in WDPs surface soils include Ra-226, Sr-90, carbon-14, cesium-137 (Cs-137), lead-210 (Pb-210), thorium-234 (Th-234), uranium-238 (U-238), Cr-VI and mercury. Only Cs-137 exceeded two times background in more than 10% of the surface soil samples. Alpha- plus gamma-chlordane were detected in most surface samples, at a maximum concentration of 2.2 milligrams per kilogram (mg/kg) in a sample collected from Pen E-7.

Radionuclides and metals detected above background in subsurface soil include Sr-90, Cs-137, C-14, Th-234, uranium-235, U-238 Pb-210 and Cr-VI. No radionuclide was detected at

greater than two times background in more than 10% of the subsurface samples. In the 1994 investigation, a sample collected from 20 ft bgs near the center of the WDPs had a Ra-226 activity of 5.11 pCi/g. However, no subsurface samples collected during the 1997/1998 investigation had Ra-226 activities greater than background, including a sample collected within a few feet of the previous sample with 5.11 pCi/g activity. Cr-VI was detected at greater than two times background in one or more sampling depths from 17 of the 20 boreholes; however, no relationship of concentration with depth was observed. Chlordane concentrations attenuated markedly with depth, and were below the detection limit in all of the soil samples collected from greater than 2 ft bgs. Mercury concentrations also attenuated sharply with depth.

3.3.1.2 Eastern Dog Pens

The nature and extent of contamination in the EDPs soil is based on the investigation conducted in 1999 and presented in the *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (Weiss, 1999c). As described in Section 3.2.2, soil from 19 of the 96 EDPs (20%) was sampled and analyzed for COPCs. Three of these pens were chosen based on elevated gamma survey readings and the remaining 16 were selected at random. Results for the EDPs are similar to those for shallow soil in the WDPs. Of the eleven radionuclides detected, only Sr-90 exceeded two times background in more than 10% of the soil samples. Mercury was detected at 0.09 to 14.6 mg/kg. No comparison was made with background because the mercury background concentration has not been accepted by the RPMs. Dieldrin was detected in 13 of 37 samples, at a maximum concentration of 223 micrograms per kilogram (µg/kg). As discussed in greater detail in Section 3.4, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha- and gamma-chlordane, endrin, endrin ketone, PCB-1254 and PCB-1260 were all detected in the EDPs soil but are well below their risk-based target levels.

3.3.2 Gravel

Alpha- plus gamma-chlordane was detected in 39 out of 46 gravel samples collected from the WDPs. Concentrations ranged from 0.0003 mg/kg (or 0.3 µg/kg) to 0.099 mg/kg. The pesticides 4,4'-DDD and 4,4'-DDT were detected at trace concentrations (0.004 mg/kg or less) in several gravel samples. Sample results for the WDPs are summarized in Table 3-2.

Sixteen gravel samples were collected from the EDPs and analyzed for Ra-226 and Sr-90. Ra-226 was detected in all gravel samples with activities ranging from 0.196 to 0.396 pCi/g. Sr-90 was detected in two gravel samples at 0.032 and 0.201 pCi/g. Table 3-2 summarizes the gravel sample results for the EDPs.

3.3.3 Curbing

As mentioned in Section 3.2, the six EDPs curb sample locations were based on gamma/beta/alpha survey results. Three locations had relatively low readings, which were less than 2,100 disintegrations per minute per 100 square centimeters (dpm/100 cm^2) beta/gamma and

150 dpm/100 cm^2 for alpha. The other three locations had elevated readings of 13,000 dpm/100 cm^2 beta/gamma and 1300 dpm/100 cm^2 alpha, 26,000 dpm/100 cm^2 beta/gamma and 52,000 dpm/100 cm^2 beta/gamma.

The purpose of the curb sampling was to determine if: 1) the two radionuclides known to have been used in the Dog Pens have impacted the curbs and 2) field gamma readings can be used as an indicator of elevated gamma/beta emitters in the curbs. The Ra-226 results from the locations with relatively low survey data ranged from 0.269 to 0.96 pCi/g, and the Ra-226 results from the locations with elevated readings ranged from 0.354 to 1.68 pCi/g. Results from the locations with relatively low survey data had up to 1.59 pCi/g Sr-90 and the samples with elevated survey readings had Sr-90 activity up to 7.44 pCi/g. Table 3-2 is a more detailed summary of the curb samples collected from the EDPs.

3.4 Risk Evaluation

3.4.1 Methods

A statistical evaluation of the WDPs soil was presented in the *Draft Technical Memorandum: Statistical Comparison of Western Dog Pens Soil Data with Risk-Based Target Levels* (Weiss, 1999b). The EDPs soil statistical evaluation was presented in the *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (Weiss, 1999c). The work plans for the 1997/1998 WDPs investigation (Weiss, 1997e and 1998b), the 1994 WDPs investigation (Dames & Moore, 1994) and the 1999 EDPs investigation (Weiss, 1999c) were prepared to CERCLA standards and approved by the RPMs. All laboratory analyses were performed using the methods specified in the approved work plans. For these reasons, these data sets were used in the statistical evaluation of the Dog Pens soil.

Statistical methods were selected for comparing WDPs and EDPs soil analytical data with background soil levels and/or the lowest RBASs to evaluate the need, if any, for further action with respect to soil in the Dog Pens. The statistical approach described here was based on *Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference Based Standard for Soil and Solid Media* (US EPA, 1994b). This is the same approach described in Appendix A of *Sampling and Analysis Plan for Removal Actions in Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic Tanks* (Weiss, 1999a). This approach was suggested and approved by the LEHR RPMs for confirmation that cleanup standards had been reached following removal actions in the Southwest Trenches (US EPA, 1998b). The overall data evaluation approach is shown in Figure 3-4. As shown in this figure, the approach consists of first determining which COPCs in soil are at levels statistically above soil background levels. All COPCs identified as potentially above-background are then compared with the lowest RBAS values.

In general, all constituents with validated concentrations above the reporting limit in one or more soil samples were included in the statistical analyses. Several general inorganic chemicals

(nitrogen compounds other than nitrate and/or sulfate) were not included. In addition, short-lived (i.e., 10 hours or less) radionuclide daughter products (actinium-228, bismuth-212, bismuth-214, lead-212, lead-214 and thallium-208) were not included. Tables 3-3 and 3-4 show all the constituents evaluated for the WDPs and EDPs, respectively. Although EPA guidance (US EPA, 1990) allows for exclusion of COPCs detected at a frequency of less than 5%, all COPCs with one or more detection were retained. The use of qualified data followed the procedures outlined in *Risk Assessment Guidance for Superfund Part A* (US EPA, 1989a), as described in *Draft Final Determination of Risk-Based Action Standards for DOE Areas* (Weiss, 1997d).

As recommended in *Statistical Methods for Evaluating the Attainment of Cleanup Standards* (EPA, 1994b), the Wilcoxon Rank Sum (WRS) test was the primary method used to determine whether residual contaminant levels meet the cleanup criteria. Because the WRS test requires a minimum number of samples to be statistically valid, data sufficiency was evaluated using the formula developed by Noether (Noether, 1987). For given decision errors α (in this case, 0.1) and β (0.2), and given Δ (0.3), this minimum number of samples depends primarily on the variances of the COPC background and WDPs distributions. For COPCs with depth-stratified background distributions, the 0-to-4 ft bgs ("shallow") and the >4 ft bgs ("deep") background and WDPs COPC distributions were compared separately using the WRS test. For non-stratified COPCs, soil data from all depths were used in the WRS tests.

In response to EPA comments on *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (Weiss, 1999c), one-dimensional (1D) contaminant transport modeling was performed to assess potential ground water impacts resulting from downward migration of contaminants through unsaturated sediments beneath the EDPs and WDPs. A ground water goal was established for each constituent and iterative modeling runs were conducted to determine the allowable soil concentration that would produce a peak ground water concentration equivalent to the ground water goal.

The numerical computer-code Non-Isothermal, Unsaturated Flow and Transport (NUFT) (Nitao, 1998) was used to develop 1D models representing the soil profiles beneath the EDPs and WDPs. The modeling presented in the *Addendum to Former Dog Pens Technical Memoranda* (Weiss, 2000a) uses methods and assumptions developed during previous modeling at the Site, as discussed in reports on previous vadose zone modeling (Weiss, 1997f, 1997d and 1998b). For each COPC, the maximum concentrations detected in the EDPs and WDPs were compared with the "allowable soil concentration" calculated with the model.

3.4.2 Results

3.4.2.1 Western Dog Pens Soil and Ground Water Impacts

Table 3-3 summarizes the WDPs soil statistical analyses. Based on these statistical analyses, only heptachlor epoxide in WDPs soil exceeds the risk-based target levels for LEHR soil, as indicated by the reasonable maximum exposure (RME) level (defined as the 95% upper confidence limit on the mean) exceeding the lowest RBAS. However, it appears that the heptachlor epoxide

RBAS is overly conservative and not appropriate for the WDPs soil, as discussed in the *Draft Technical Memorandum: Statistical Comparison of Western Dog Pens Soil Data with Risk-Based Target Levels* (Weiss, 1999b).

The results of the ground water impact modeling for the WDPs are presented in Table 3-5. All of the COPC maximum detected levels except mercuric sulfide were significantly below the calculated allowable soil levels. The maximum mercuric sulfide level detected in WDPs soil is 3.7 mg/kg, above the allowable soil concentration of 0.62 mg/kg. Because the maximum mercuric sulfide concentration detected in the WDPs soil exceeded the allowable soil concentration calculated from the model, another round of modeling was conducted using a more reasonable and less conservative mercuric sulfide concentration in the WDPs shallow soil. The RME level for mercuric sulfide concentrations in excess of background in WDPs soil was calculated. Based on this approach, the RME level for "added" mercury is 0.57 mg/kg, which is less than the calculated allowable soil concentration of 0.62 mg/kg. This result, in addition to an arrival time for the peak ground water concentration of 5,927 years, suggests mercuric sulfide is not a concern in terms of ground water impact. The ground water modeling is discussed in more detail in the *Addendum to Former Dog Pens Technical Memoranda* (Weiss, 2000a).

3.4.2.2 Eastern Dog Pens Soil and Ground Water Impacts

Table 3-4 summarizes the EDPs soil statistical analyses. Based on these statistical analyses, no COPC in the EDPs soil exceeds the risk-based target levels for LEHR soil. The statistical evaluation of the EDPs is discussed in more detail in the *Technical Memorandum: Investigative Results for the Former Eastern Dog Pens* (Weiss, 1999c).

The results of the ground water impact modeling in the EDPs are presented in Table 3-5. All of the detected COPCs, except mercuric sulfide, were significantly below the calculated allowable soil levels. The calculated allowable soil concentration for mercuric sulfide is 0.94 mg/kg, which is less than the maximum detected total mercury concentration of 14.6 mg/kg. Because the maximum mercuric sulfide concentration detected in the EDPs soil exceeded the allowable soil concentration calculated from the model, another round of modeling was conducted using a more reasonable and less conservative mercuric sulfide concentration in the EDPs shallow soil. The RME level for mercuric sulfide concentrations in excess of background in EDPs soil was calculated. Based on this approach, the RME level for "added" mercury is 0.94 mg/kg, which is the same as the calculated allowable soil concentration. Based on the very low solubility and overall conservative nature of this model, mercuric sulfide is not a concern in terms of ground water impact. In addition, the modeled arrival time for the peak ground water concentration is 6,420 years.

3.4.2.3 Western and Eastern Dog Pens Gravel

No background levels or risk-based target levels have been developed for gravel. Statistical comparison shows that radionuclide and metals levels in the WDPs and EDPs are similar to those in background soils (Weiss, 1999b, 1999c).

3.4.2.4 Concrete Curbing

Site background activities for Ra-226 and Sr-90 in concrete have not been established. Ra-226 activity levels in concrete reported in the literature ranges from 0.7 pCi/g to 2.65 pCi/g (Kahn, 1993, Ingersoll, 1983, Tso, 1994). In the absence of information on the typical range of Sr-90 activity in concrete, it is expected that its background activity in concrete is well below 1 pCi/g since Sr-90 does not occur naturally.

The Ra-226 results from the locations with background survey data ranged from 0.269 to 0.96 pCi/g, and the Ra-226 results from the locations with elevated readings ranged from 0.354 to 1.68 pCi/g. Hence, the Ra-226 activity in the EDPs curbs is similar to the background activity of 0.7 pCi/g to 2.65 pCi/g from the literature. The Sr-90 results from the locations with background survey data had activity up to 1.59 pCi/g, and the Sr-90 results from the samples with elevated survey readings had Sr-90 activity up to 7.44 pCi/g. Only three of the six curb samples had measurable Sr-90 activity.

3.5 Conclusions

Based on our statistical evaluation of the WDPs and EDPs soil data, all COPCs are at or below the appropriate soil target levels, defined as the lowest appropriate RBAS, or background for those COPCs with background levels higher than the lowest RBAS. In addition, many of the WDPs soil sample locations were selected specifically to target areas that were suspected to have elevated COPC levels. Accordingly, use of these data in the statistical analysis and comparisons with RBASs yields results are more health-conservative than a random sample set. The ground water impact evaluation also indicated that potentially above-background constituents in the EDPs and WDPs soil will not impact underlying ground water above the ground water goals. Based on these evaluations, no RA is needed for WDPs or EDPs soil.

Radionuclide and metals levels in the Dog Pens gravel are generally similar to those in background soils; however, no gravel-specific background levels have been determined. To properly evaluate the gravel, several gravel samples must be collected off-site and analyzed in order to calculate gravel-specific background levels. Also, the existing laboratory results are for total gravel analyses, and may not be representative of potentially elevated surface levels. Therefore, existing gravel data are not sufficient to support a no removal decision. Based on the limited data set, conclusions about the concrete curbing also cannot be drawn without additional sampling.

Table 3-1. Number of Samples per Depth Interval for 1994 and 1997/1998 Former Western Dog Pens Soil Samples

	Number of Samples Per Analytic Suite				
Depth Interval	Radionuclides[1]	Metals[1]	Chromium VI	Nitrate	Pesticides[1]
0 - 2 ft.	126	119	124	119	122
2 - 4 ft.	4	4	9	4	4
4 - 12 ft	38	36	36	36	35
12 - 20 ft.	21	20	20	20	21
20 - 40 ft.	22	21	21	21	22

Notes:

[1] For radionuclides, pesticides and metals, the number of samples given is for the most frequently analyzed constituent(s) from that analytic suite for that depth interval.

Table 3-2. Summary of Analytic Results for the Concrete Curb and Gravel Samples from the Former Western and Eastern Dog Pens Investigations

Constituent	Radiation Survey Results	Units	No. of Samples Analyzed	No. of Samples Above Reporting Limit[1]	Min. Activity/ Conc.[2]	Max. Activity/ Conc.	Average Activity/ Conc.[3]	Sample ID w/ Max. Conc.	Dog Pen No. w/ Max. Conc.
Curb Samples									
Radium-226	Bkgd.	pCi/g	3	3	0.269	0.96	0.519	CSDP0001	M30/31
Radium-226	Elevated	pCi/g	3	3	0.354	1.68	0.872	CSDP0002	M30/31
Strontium-90	Bkgd.	pCi/g	3	1	<0.05	1.59[4]	0.805	CSDP0006	L3/4
Strontium-90	Elevated	pCi/g	3	2	0.398[4]	7.44[4]	3.13	CSDP0005	L3/3
Eastern Dog Pens Gravel Samples									
Radium-226	NA	pCi/g	16	16	0.196	0.396	0.291	GSDP0016	M22
Strontium-90	NA	pCi/g	16	2	0.0324	0.201	0.029	GSDP0004	L2
Western Dog Pens Gravel Samples									
Radium-226	NA	pCi/g	46	38	0.086	1.94	0.625	LEHRSSDP-0072	C-32
Strontium-90	NA	pCi/g	46	4	0.009	3.59	0.363	LEHRSSDP-0072	C-32
Uranium-238	NA	pCi/g	46	15	0.058	1.2	0.438	LEHRSSDP-0098	H-32
Chlordane-alpha +gamma	NA	mg/kg	46	39	0.0003	0.103	0.009	LEHRSSDP-0075	D-20
Hexavalent chromium	NA	mg/kg	46	18	0.18	0.451	0.21	LEHRSSDP-0077	D-27

Notes:

[1] Number of samples above Reporting Limit represents the number of samples greater than the "detection units" for volatile and semi-volatile organic compounds, pesticides, the instrument detection limit for metals, the minimum detection limit for general chemistry, and the minimum detectable activity for radionuclides.

[2] Minimum value above laboratory reporting limit.

[3] The average of all detected concentrations including concentrations below the reporting limit. If the sample results were censored, half the detection limit was used to calculate the average.

[4] Average of two analytic results for the same sample

Abbreviations:

Bkgd. Background
Conc. Concentration
Min. Minimum
Max. Maximum
No. Number
NA Not applicable
W/ With

Table 3-3. Statistical Comparison of Soil Analytical Data Collected from the Former Western Dog Pens

Constituent	Total No. of Samples	No. above Reporting Limit	Range (Min.-Max.)	Background[1]	Statistical Comparison with Background[2]	Lowest RBAS[3]	Max. Detection Below Lowest RBAS[4]	RME	RME Level below Lowest RBAS[5]	Overall Comparison with Target Levels	PRG[6]
Radionuclides			**pCi/g**	**pCi/g**		**pCi/g**					**pCi/g**
Carbon-14	200	7 (<5%)	<0.695-16.4	NA	NA	4200	**Pass**		---	**Pass**	770
Cesium-137	199	44	<0.02-0.115	0.102/0.007[7]	**Pass**/Pass(Q)	0.1	---/**Pass**		---	**Pass**	0.02
Lead-210	199	18	<0.21 - 4.96	1.6	Fail(Q)	9.6	**Pass**		---	**Pass**	0.78
Potassium-40	198	198	4.1-16.4	14	**Pass**	NE	---		---	**Pass**	0.068
Radium-226	200	183	<0.019-5.11	0.752	**Pass**	0.0042	---		---	**Pass**	0.0062
Strontium-90	200	8 (<5%)	<0.236-0.712	0.056	Fail(Q)	10	**Pass**		---	**Pass**	14
Thorium-234	199	59	<0.24-2.4	0.78	Fail	3.2[8]	**Pass**		---	**Pass**	0.69
Uranium-235	198	10 (<5%)	<0.13-0.317	0.0638	Fail(Q)	0.15	Fail	0.071	**Pass**	**Pass**	0.16
Uranium-238	169	60	<0.24-2.4	0.565/0.645	Fail(Q)/Fail(Q)	3.2[8]	**Pass**		---	**Pass**	18
Metals			**mg/kg**	**mg/kg**		**mg/kg**					**mg/kg**
Barium	30	6	<200-219	211/294	**Pass/Pass**	53	---		---	**Pass**	5200
Total Chromium	63	63	43.9-273	199/125	**Pass**/Fail	722	---/**Pass**		---	**Pass**	210
Hex. Chromium	210	39	<0.206-1.02	0.054	Pass(Q)	3.8	**Pass**		---	**Pass**	30 (0.2)
Copper	30	25	<25-46.8	48.8/61.8	**Pass/Pass**	28	---		---	**Pass**	2800
Iron	30	30	21,000-46,600	44,000	Fail	NE	(NE)		(NE)	Indeterminate	22,000
Lead	30	30	4.1-10.8	9.5	**Pass**	0.044	---		---	**Pass**	400 (130)
Manganese	30	30	379-1010	750	**Pass**	36	---		---	**Pass**	3100
Mercury	201	128	<0.03-3.7	3.94/0.248	**Pass**/Pass(Q)	5.75[8]	---/**Pass**		---	**Pass**	22
Nickel	30	30	62.9-318	334/246	**Pass**/Fail	NE	---/(NE)		---/(NE)	Indeterminate[9]	1,500 (150)
Vanadium	30	30	34.7-77.5	66.8/80.3	**Pass/Pass**	NE	---		---	**Pass**	520
Zinc	30	30	42.8-130	72.4/93.1	Pass(Q)/**Pass**	3400	**Pass**/---		---	**Pass**	22,000

Table 3-3. Statistical Comparison of Soil Analytical Data Collected from the Former Western Dog Pens (continued)

Constituent	Total No. of Samples	No. above Reporting Limit	Range (Min.-Max.)	Background[1]	Statistical Comparison with Background[2]	Lowest RBAS[3]	Max. Detection Below Lowest RBAS[4]	RME	RME Level below Lowest RBAS[5]	Overall Comparison with Target Levels	PRG[6]
Pesticides			**ug/kg**	**ug/kg**		**ug/kg**					**ug/kg**
Alpha-BHC	197	1 (<5%)	<1.9-11	NA	NA	7.5	Fail	1.57	**Pass**	**Pass**	86
Chlordane-alpha+gamma	197	85	<1.5-1- 2186	NA	NA	780	Fail	57	**Pass**	**Pass**	1600
Heptachlor Epoxide	197	8 (<5%)	<1.8-13.4	NA	NA	0.57	Fail	1.91	Fail	Fail	49
Inorganics			**mg/kg**	**mg/kg**		**mg/kg**					**mg/kg**
Nitrate	200	189	<0.197-59	36	Pass (Q)	NE	(NE)		(NE)	Pass(Q)	NE

Notes:

[1] Site-specific background levels, as presented in Appendix C from "Sampling and Analysis Plan for Removal Actions in the Southwest Trenches, Ra/Sr Treatment Systems, and Domestic Septic System Areas" (WA, 1999f); "NA" indicates not available.

[2] Using Wilcoxon Rank Sum Test (WRS) with previously approved parameters; "Pass" indicates Former Western Dog Pens distribution statistically does not exceed the background distribution; "Q" indicates result is qualified due to insufficient data for WRS test based on Noether calculation.

[3] Lowest RBAS from "Draft Final Determination of Risk-Based Action Standards for DOE Areas" (WA, 1997b); "NE" indicates none established.

[4] "Pass" indicates maximum Western Dog Pens (WDPs) level is lower than lowest RBAS; "---" indicates comparison not made because constituent passes comparison with background.

[5] "Pass" indicates reasonable maximum exposure (RME) level, defined as the 95% upper confidence limit (UCL) on the mean, of WDPs data is lower than lowest RBAS; "---" indicates comparison not made because constituent passed previous comparison.

[6] USEPA Region IX Preliminary Remediation Goals, August and December, 1996, at 1 x 10^{-6} risk for residential scenario; California Modified Preliminary Remediation Goals in parentheses; "NE" indicates none established.

[7] Where two background values are given, first is for surface to 4 feet below ground surface (ft bgs) soil, second is for >4 ft bgs soil.

[8] This new RBAS value is for mercuric sulfide and mercuric chloride. It is the result of RBAS recalculation presented in *Addendum to Former Dog Pens Technical Memoranda* (WA, 2000) and has not been approved by the RPMs.

[9] Indeterminate for samples greater than 4 ft bgs.

Table 3-4. Statistical Comparison of Soil Analytical Data Collected from the Former Eastern Dog Pens

Constituent	Total No. of Samples	No. above Reporting Limit	Range of Reporting Limits	Min. and Max. of Detections	Bkgd. [1]	Statistical Comparison with Bkgd.[2]	Lowest RBAS[3]	Max. Detection Below Lowest RBAS[4]	RME[5]	RME below Lowest RBAS[6]	Overall Comparison with Target Levels	PRG[7]
Radionuclides			**pCi/g**	**pCi/g**	**pCi/g**		**pCi/g**					**pCi/g**
Cesium-137	37	31	0.004-0.007	0.0048-0.191	0.102	Pass (Q)	BG [8]	Fail	0.05	**Pass**	**Pass**	0.02
Radium-226	37	37	0.024-0.058	0.355-0.734	0.752	**Pass**	BG	---	---	---	**Pass**	0.0062
Strontium-90	37	12	0.0145-0.0491	0.023-0.164	0.056	Fail (Q)	10	**Pass**	---	---	**Pass**	14
Thorium-228	37	37	0.158-0.37	0.225-1.54	0.627	**Pass**	BG	---	---	---	**Pass**	0.041
Thorium-230	37	37	0.0319-0.17	0.288-1.26	1.04	**Pass**	NE	---	---	---	**Pass**	20
Thorium-232	37	37	0.0267-0.153	0.234-1.39	0.63	**Pass**	BG	---	---	---	**Pass**	24
Thorium-234	37	37	0.0804-0.34	0.357-0.89	0.78	**Pass**	3.2 [9]	---	---	---	**Pass**	0.69 [9]
Metals			**mg/kg**	**mg/kg**	**mg/kg**		**mg/kg**					**mg/kg**
Total Chromium	37	37	2-2.4	90.7-251	199	Fail	722	**Pass**	---	---	**Pass**	210
Hex. Chromium	37	36	0.0347-0.0432	0.077-0.673	0.054	Fail (Q)	3.8	**Pass**	---	---	**Pass**	30 (0.2)
Mercury	37	37	0.029-0.38	0.09-14.6	3.94	Pass (Q)	BG	Fail	1.95	**Pass**	**Pass**	22
Pesticides			**ug/kg**	**ug/kg**	**ug/kg**		**ug/kg**					**ug/kg**
4,4'-DDD	37	7	3.4-3.9	0.82-3.3 [10]	NA	NA	7948	**Pass**	---	---	**Pass**	2400
4,4'-DDE	37	3	3.4-3.9	0.3-3.6 [10]	NA	NA	5610	**Pass**	---	---	**Pass**	1700
4,4'-DDT	37	5	3.4-3.9	0.48-5.8 [10]	NA	NA	5610	**Pass**	---	---	**Pass**	1700
Chlordane-alpha + gamma	37	12	1.7-3.7	0.78-91.2[10]	NA	NA	780	**Pass**	---	---	**Pass**	1600
Dieldrin	37	13	3.4-18.1	0.76-223 [10]	NA	NA	15.25	Fail	5.65	**Pass**	**Pass**	28
Endrin	37	1 (<5%)	3.7	6.2	NA	NA	NE	(NE)		(NE)		16
Endrin Ketone	37	1 (<5%)	3.6	2.7 [10]	NA	NA	NE	(NE)		(NE)		NE
PCB-1254	37	2	39.2	24.3-54.9 [10]	NA	NA	NE	(NE)		(NE)		97
PCB-1260	37	1 (<5%)	38.8	6.9 [10]	NA	NA	247.74	**Pass**	---	---	**Pass**	200

Table 3-4. Statistical Comparison of Soil Analytical Data Collected from the Former Eastern Dog Pens (continued)

Constituent	Total No. of Samples	No. above Reporting Limit	Range of Reporting Limits	Min. and Max. of Detections	Bkgd. [1]	Statistical Comparison with Bkgd.[2]	Lowest RBAS[3]	Max. Detection Below Lowest RBAS[4]	RME[5]	RME below Lowest RBAS[6]	Overall Comparison with Target Levels	PRG[7]
Inorganics			**mg/kg**	**mg/kg**	**mg/kg**		**mg/kg**					**mg/kg**
Nitrate	37	31	0.126-0.156	0.351-10.1	36	Pass (Q)	NE	(NE)		(NE)	Pass (Q)	NE

Notes:

[1] Site-specific background levels, as presented in Appendix C from "Sampling and Analysis Plan for Removal Actions in the Southwest Trenches, Radium/Strontium Treatment Systems, and Domestic Septic System Areas" (WA, 1999f); "NA" indicates not available.

[2] Using Wilcoxon Rank Sum Test (WRS) with previously approved parameters; "Pass" indicates Former Eastern Dog Pens (EDPs) distribution statistically does not exceed the background distribution; "Q" indicates result is qualified due to insufficient data for WRS test based on Noether calculation.

[3] Lowest RBAS from "Draft Final Determination of Risk-Based Action Standards for DOE Areas" (Weiss Associates, 1997b); "NE" indicates none established.

[4] "Pass" indicates maximum EDPs level is lower than lowest Risk-Based Action Standards (RBAS); "---" indicates comparison not made because constituent passes comparison with background.

[5] RME = reasonable maximum exposure level, defined as the 95% upper confidence level (UCL) on the mean.

[6] "Pass" indicates 95% UCL on the mean of EDPs data is lower than lowest RBAS; "---" indicates comparison not made because constituent passed previous comparison.

[7] USEPA Region IX Preliminary Remediation Goals, August and December, 1996, at 1 x 10^{-6} risk for residential scenario; California Modified Preliminary

[8] "BG" indicates the lowest calculated RBAS is less than the background level. Therefore, the lowest RBAS is defined as background.

[9] RBAS and PRG for U-238 + Th-234.

[10] Any values below reporting limits are estimated values (Most of the concentrations for pesticides are below reporting limits).

Additional Abbreviations:

Bkgd. Background
Max. Maximum
Min. Minimum
No. Number

Table 3-5. Evaluation of Potential Ground Water Impact from Above-Background Constituents in Dog Pens Soil

Constituent	No. above RL/Total Samples	Range of RL	Min. and Max. of Detections	Bkgd. [1]	Ground Water Goal[2]	Allowable Soil Concentration[3]	Max. Detection Below Allowable Soil Concentration[4]	RME Concentration[5]	RME Below Allowable Soil Concentration	Tap Water PRG[10]
EASTERN PENS										
Radionuclides		**pCi/g**	**pCi/g**	**pCi/g**	**pCi/L**	**pCi/g**				
Strontium-90	12/37	0.0145-0.0491	0.023-**0.164**	0.056	8 (MCL)	**1.72E+15**	Pass	0.04	**Pass**	NE
Metals		**mg/kg**	**mg/kg**	**mg/kg**	**µg/L**	**mg/kg**				**µg/L**
Hex. Chromium	36/37	0.0347-0.0432	0.077-**0.673**	0.054	20.0 (Bkgd.[7])	**2.56**	Pass	0.26	**Pass**	180
Methyl Mercury	37/37	NE	0.00009-**0.0089**[9]	NE	3.7 (PRG)	**1.6**	Pass	0.02	**Pass**	3.7
Elemental Mercury	37/37	NE	0.0003-**0.033**[9]	NE	2 (MCL)	**0.97**	Pass	0.07	**Pass**	NE
Mercuric Sulfide	37/37	0.029-0.38	0.09-**14.6**[9]	NE	2 (MCL)	**0.94**	**Fail**	**0.94**	**Pass**	55[11]
Pesticides		**µg/kg**	**µg/kg**	**µg/kg**	**µg/L**	**µg/kg**				**µg/L**
4,4'-DDD	7/37	3.4-3.9	0.82-**3.3** [6]	0	0.28 (PRG)	**4,900**	Pass	3.3	**Pass**	0.28
4,4'-DDE	3/37	3.4-3.9	0.3-**3.6** [6]	0	0.20 (PRG)	**24,400**	Pass	3.6	**Pass**	0.20
4,4'-DDT	5/37	3.4-3.9	0.48-**5.8** [6]	0	0.20 (PRG)	**9,890**	Pass	5.8	**Pass**	0.20
Chlordane-alpha	12/37	1.78-3.7	0.38-**47.8** [6]	0	0.05 (MCL[12])	**110,000**	Pass	5.2	**Pass**	0.095[12]
Chlordane-gamma	12/37	1.7-3.7	0.4-**43.4** [6]	0	0.05 (MCL[12])	**2.45E+7**	Pass	4.7	**Pass**	0.095[12]
Dieldrin	13/37	3.4-18.1	0.76-**223** [6]	0	0.0042 (PRG)	**25,000**	Pass	19.3	**Pass**	0.0042
PCB-1254	2/37	39.2	24.3-**54.9** [6]	0	0.50 (MCL)	**10,100**	Pass	54.9	**Pass**	0.73
Constituent	Total No. of Samples	Range of Detections		Bkgd. [1]	Ground Water Goal[2]	Allowable Soil Concentration[3]	Max. Detection Below Allowable Soil Concentration[4]	RME Concentration[5]	RME Below Allowable Soil Concentration	Tap Water PRG[10]
WESTERN PENS										
Radionuclides		**pCi/g**		**pCi/g**	**PCi/L**	**pCi/g**				**µg/L**
Lead-210	18/199	<0.21-**4.96**		1.6	50 (MCL)	**1.12E+40**	Pass	1.3	**Pass**	NE
Strontium-90	8 (<5%)/200	<0.236-**0.712**		0.056	8 (MCL)	**3.28E+18**	Pass	0.71	**Pass**	NE
Uranium-235	10 (<5%)/198	<0.13-**0.317**		0.0638	2 (MCL[8])	**2.67**	Pass	0.32	**Pass**	NE
Uranium-238	60/169	<0.24-**2.4**		0.565/0.645	20 (MCL)	**150**	Pass	0.77	**Pass**	NE

Table 3-5. Evaluation of Potential Ground Water Impact from Above-Background Constituents in Dog Pens Soil (continued)

Constituent	Total No. of Samples	Range of Detections	Bkgd. [1]	Ground Water Goal[2]	Allowable Soil Concentration[3]	Max. Detection Below Allowable Soil Concentration[4]	RME Concentration[5]	RME Below Allowable Soil Concentration	Tap Water PRG[10]
Metals		**mg/kg**	**mg/kg**	**µg/L**	**mg/kg**				**µg/L**
Methyl Mercury	128/201	<0.00003-**0.0037**[9]	NE	3.7 (PRG)	**1.39**	Pass	0.01	**Pass**	3.7
Elemental Mercury	128/201	<0.0001-**0.014**[9]	NE	2 (MCL)	**0.82**	Pass	0.03	**Pass**	NE
Mercuric Sulfide	128/201	<0.03-**3.7**[9]	NE	2 (MCL)	**0.62**	**Fail**	**0.57**	**Pass**	55[11]
Pesticides		**µg/kg**	**µg/kg**	**µg/L**	**µg/kg**				
Chlordane-alpha	84/197	<1.5-**1210**	0	0.05 (MCL[12])	**59,000**	Pass	36.3	**Pass**	0.095[12]
Chlordane-gamma	85/197	<1.5-**976**	0	0.05 (MCL[12])	**1.32E+7**	Pass	33.8	**Pass**	0.095[12]

Notes:

[1] Site-specific background levels, as presented in Appendix C from "Sampling and Analysis Plan for Removal Actions in the Southwest Trenches, Radium/Strontium Treatment Systems, and Domestic Septic System Areas" (WA, 1999f); "NA" indicates not available.

[2] "Ground Water Goal" is the lower of U.S. Environmental Protection Agency or California Department of Health Services maximum contaminant level (MCL) for drinking water; for those constituents without an MCL, the goal is either the USEPA Region IX Tap Water PRG or background, whichever is higher.

[3] Soil concentration that, based on Non-isothermal, Unsaturated Flow and Transport (NUFT) vadose zone modeling, results in peak ground water concentration equal to the "Ground Water Goal," with peak times ranging from 660 years (Sr-90) to 1,000,000 years (DDE).

[4] "Pass" indicates maximum Dog Pens soil level is lower than "Allowable Soil Concentration".

[5] Reasonable maximum exposure (RME) concentration is reasonable exposure concentration, defined as 95% upper confidence limit on the mean of mercury in excess of background. Background is assumed to be 0.44 mg/kg, the average concentration for shallow background samples collected before 1999. The RME is the 95% UCL for constituents of concern (COCs) with 10 detections and a number of detections greater than 5% of the total samples collected; the RME is equal to the highest detected concentration for COCs with less 10 detections (<5%).

[6] Any values below reporting limits are estimated values. (Most of the concentrations for pesticides are below reporting limits.)

[7] Hexavalent chromium background level in ground water is based on recent ground water monitoring data from well UCD1-18.

[8] U-235 "Ground Water Goal" set at 10% of uranium MCL based on approximate ratio of Uranium-235 to Uranium-238 in Dog Pens soil.

[9] Methyl mercury is assumed to represent 0.1% of total mercury, elemental mercury is assumed to represent 0.37% of total mercury, and mercuric sulfide is assumed to be equal to total mercury.

[10] USEPA Region IX Preliminary Remediation Goal (PRG) for tap water, 1999.

[11] Mercuric sulfide PRG tap water is assumed to be five times tap water PRG for mercury and compounds (i.e., mercuric chloride), based on mercuric sulfide bioavailability study (Rebus, 1990).

[12] MCLs and PRGs for alpha- and gamma-chlordane are one-half of MCL and PRG for total chlordane.

Abbreviations:

Bkgd.	Background	Min.	Minimum	NE	None Established	RL	Reporting Limit
Max.	Maximum	NC	Not Calculated	No.	Number		

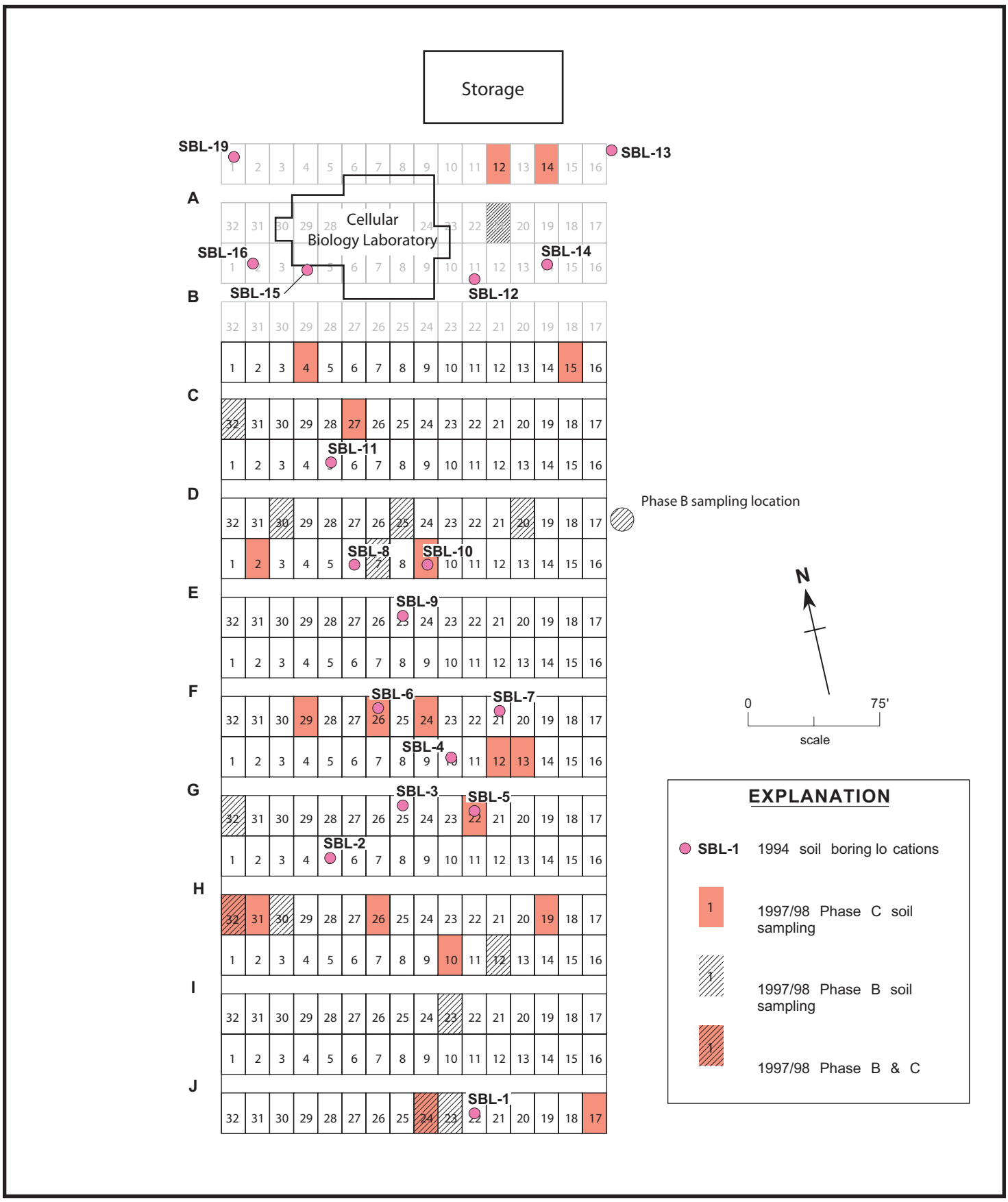


Figure 3-1. Former Western Dog Pens Soil Sampling Locations - LEHR Site, UC Davis, California

Weiss Assoc iates

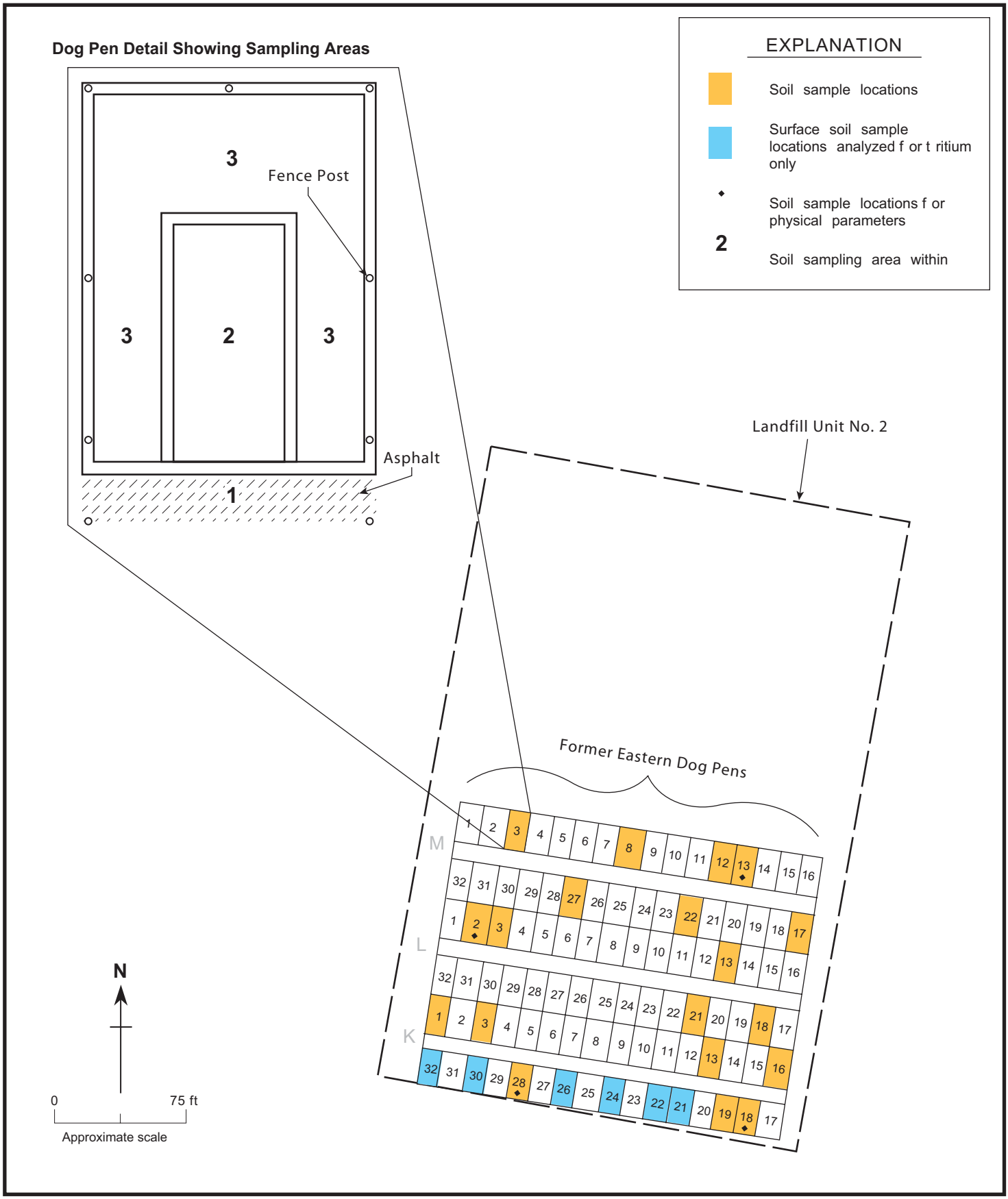


Figure 3-2. Shallow Soil Sample Locations in the Former Eastern Dog Pens, LEHR Site, UC Davis, California

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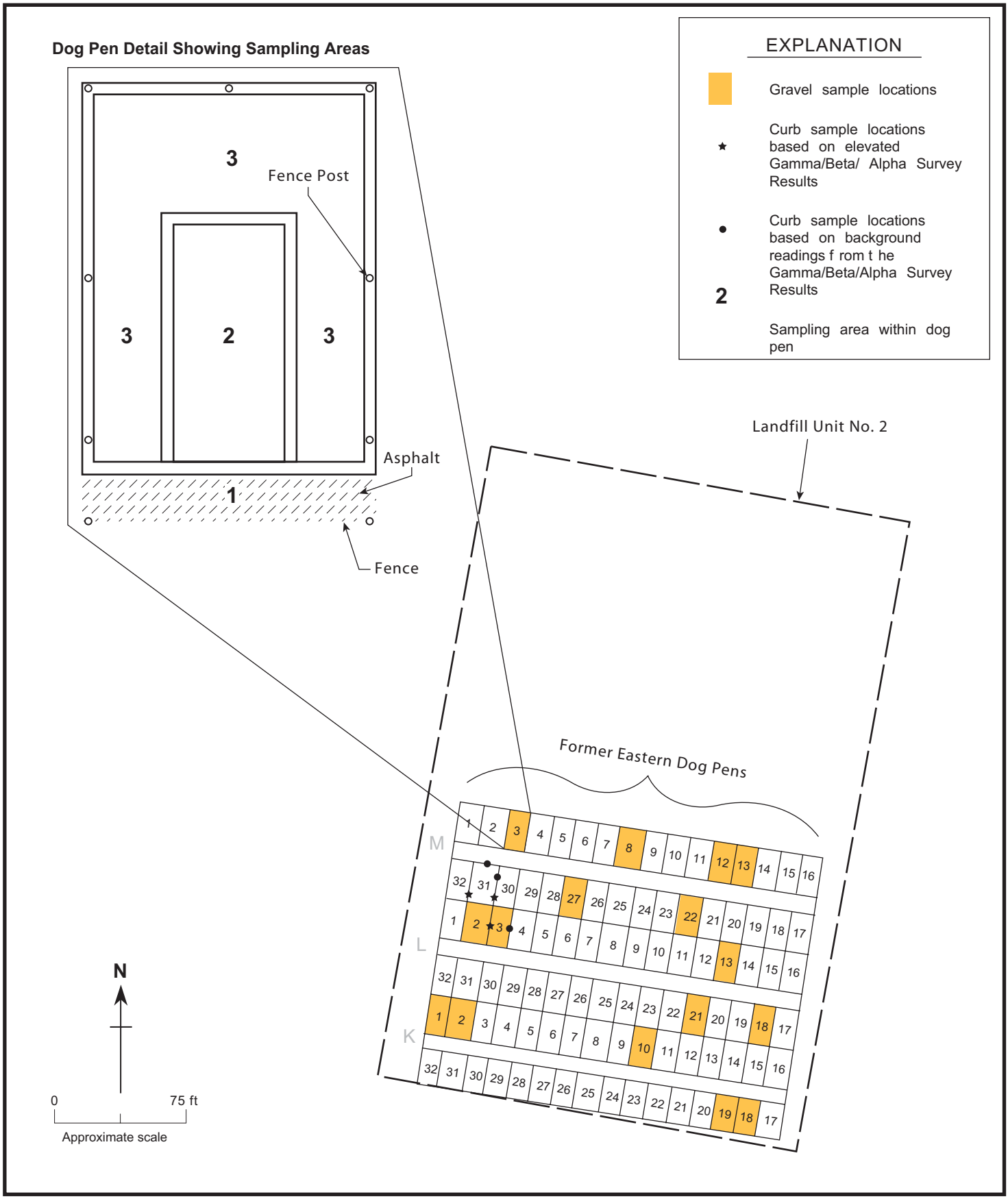

Figure 3-3. Concrete Curbing and Gravel Sample Locations in the Former Eastern Dog Pens, LEHR Site, UC Davis, California

Weiss Associates

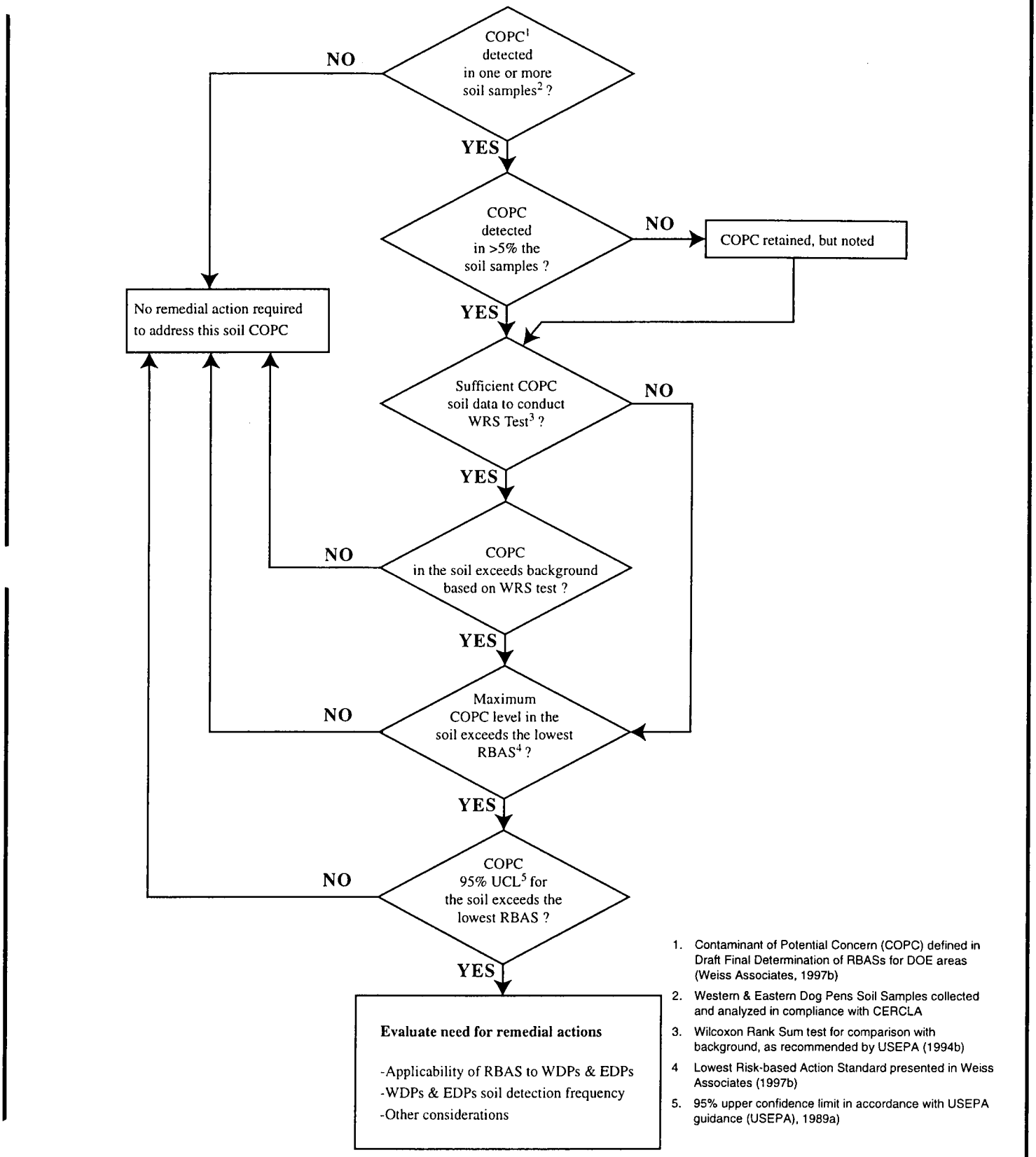

Figure 3-4. Data Evaluation Process for Western and Eastern Dog Pens Soil

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4. REMOVAL ACTION OBJECTIVES

RAOs ensure that removal alternatives achieve acceptable exposure levels that protect human health and the environment. The development of RAOs considers Applicable or Relevant and Appropriate Requirements (ARARs), CERCLA risk ranges (i.e., 10^{-4} to 10^{-6} excess cancer risk) and other pertinent factors. Specific RAOs for the WDPs and EDPs are identified at the end of this section.

4.1 Statutory Authority

Executive Order 12580 "Superfund Implementation", amended August 1996, delegates to DOE the authority for RAs at DOE sites, whether or not the sites are on the NPL (E.O., 1996). Authority for responding to releases or threats of releases from a hazardous waste site is addressed in Section 104 of CERCLA. Under CERCLA Section 104(b), DOE is authorized to undertake such investigations, surveys, testing, or other data gathering deemed necessary to identify the existence, extent and nature of the contaminants, including the extent of threats to human health and the environment. In addition, DOE is authorized to undertake planning, engineering and other studies or investigations appropriate to directing response actions to prevent, limit or mitigate the risk to human health and the environment.

4.2 Applicable or Relevant and Appropriate Requirements

4.2.1 Definition

ARARs are federal standards, requirements, criteria, limitations or more stringent state standards determined to be legally applicable or relevant and appropriate to the circumstances at a given CERCLA site. Under Section 121 of CERCLA and Section 300.400(g) of the NCP, RAs undertaken under CERCLA Section 120 must attain ARARs identified based upon an objective determination of whether the requirement specifically addresses a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance found at the Site. Only the substantive requirements are considered when determining the ARARs for on-site RA activities. Permits or approval of state or local administrative bodies (40 CFR Section 300.400(e), 42 USCA Section 9621) are not required for Site activities. Activities associated with a RA but conducted off-site must meet both the substantive and administrative requirements that are determined to be applicable. Off-site compliance does not extend to relevant and appropriate standards (40 CFR Section 300.400(f)).

- *Substantive requirements* are requirements that pertain directly to action or conditions in the environment. Substantive requirements apply to on-site actions. "On-site" includes not only the aerial extent of contamination, but also all areas in very close proximity to the contamination necessary for implementation of the response action.
- *Administrative requirements* are mechanisms that facilitate the implementation of the substantive requirement of a statute or regulation. These are interpreted broadly by EPA to include all administrative provisions from other laws, such as recordkeeping, consultation and reporting requirements.
- *Applicable requirements* are requirements promulgated under federal or state law that would be legally applicable to the RA if that action were not taken pursuant to Sections 104, 106, 120, 121 and 122 of CERCLA. These requirements directly and fully address the RA activities.
- *Relevant and appropriate requirements* are federal or state requirements that, while not legally applicable to the Site, apply to sites or circumstances sufficiently similar to the subject site that their application is appropriate because they serve to further reduce the risk posed by the CERCLA site. In some cases only a portion of the requirement may be relevant and appropriate. Only those requirements that are both relevant and appropriate must be addressed at CERCLA sites. Compliance with relevant and appropriate requirements is based on the discretion of the EPA RPM.

4.2.2 Types of ARARs

Potential ARARs to be reviewed for CERCLA sites fall into three broad categories, based on the COPC, the site location and conditions and the RA being considered. The three categories are:

- Chemical-specific ARARs—Usually health- or risk-based requirements that define acceptable concentrations of a chemical in the environment. An example of a chemical-specific ARAR is an ambient air quality standard or a maximum contaminant level (MCL) defined by the Solid Waste Disposal Act.
- Location-specific ARARs—Requirements that restrict activities in certain environmentally sensitive areas such as flood plains, wetlands, endangered species habitat or historically significant areas.
- Action-specific ARARs—Requirements that are technology or activity based. These ARARs regulate discrete actions or the design and use of certain equipment. An example of an action-specific ARAR is the Toxic Substances Control Act (TSCA) requirement to burn a specific type of waste in an incinerator that meets TSCA design and operation standards.

4.2.3 State and Local ARARs

Remedial actions must comply with ARARs which include state-promulgated environmental regulations, if any, that are more stringent than federal environmental requirements. To be considered "promulgated", a requirement must be legally enforceable, based on specific enforcement provisions or the state's legal authority and must be generally applicable. State rules must also be identified in a timely manner in order to be considered as ARARs. Local or regional requirements that are promulgated and legally enforceable by the state may also serve as ARARs.

4.2.4 To-Be-Considered Guidelines

When ARARs are not fully protective of human health and the environment, the NCP (40 CFR §300) allows for other local ordinances, unpromulgated criteria, advisories, or guidance documents to be identified to supplement the ARARs if they are helpful in achieving an acceptable level of risk. The identification of To-Be-Considered guidelines (TBCs) is not mandatory; however, it is recommended if it will assist in determining a level of cleanup that protects human health and the environment.

4.2.5 Chemical-Specific Requirements

The following are chemical-specific ARARs and TBCs for the LEHR DOE areas. These requirements are summarized in Table 4-1.

Federal Requirements

- Solid Waste Disposal Act, Resource Conservation and Recovery Act, Identification and Listing of Hazardous Waste (42 USC §6921, 40 CFR Part 261)
- Clean Water Act (33 USCA 1251-1376, 40 CFR 122, 125 and 136)
- Safe Drinking Water Act (42 USCA 300 and 40 CFR 141.11-16, 141.50-51)
- Establishment of Cleanup Levels for CERCLA Sites with Radioactive Contamination (EPA, OSWER Directive No. 9200.4-18, Aug. 22, 1997)
- Radiological Release Criteria for License Termination, (Nuclear Regulatory Commission, Federal Register, Vol. 64, No. 234, Dec. 7, 1999)

State and Local Requirements

- Criteria for Identifying Hazardous Wastes CCR, Title 22, 66261.21-33
- Porter-Cologne Water Quality Control Act (Generally, California Water Code, Div. 7, § 13000, et. seq. and 23 CCR Chap. 15, 2510-2559, 2580-2601)

- Central Valley Regional Water Quality Control Board Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites" and "Policy for Application of Water Quality Objectives"
- State Water Resources Control Board Resolution 68-16, "Anti-degradation Policy"
- State Water Resources Control Board Resolution 92-49, "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304"
- State Water Resources Control Board Resolution 88-63, "Sources of Drinking Water Policy"

4.2.6 Location-Specific Requirements

The following are location-specific ARARs and TBCs for the LEHR DOE areas. These requirements are summarized in Table 4-2.

Federal Requirements

- Endangered Species Act of 1973 (16 USC Section 1531 et seq., 50 CFR Parts 10, 11, 17, 200, 402, & 424 and 40 CFR 257.3)
- Executive Order 11988 (floodplain management) and 11990 (protection of wetlands) (40 CFR 6, 10 CFR 1022)
- National Historic Preservation Act of 1966 (16 USC 470 et seq., Public Law 89-665 and amendments of 1980, Public Law 96-515, 36 CFR 800); and,
- Fish and Wildlife Coordination Act (16 USC 661-666)

State and Local Requirements

- California Endangered Species Act, (California Fish and Game Code §2050–2068)

4.2.7 Action-Specific Requirements

The following are action-specific ARARs and TBCs for the LEHR DOE areas. These requirements are summarized in Table 4-3.

Federal Requirements

- Clean Water Act Section 404 (33USC 1344, 33CFR328 and 40 CFR 230)

- National Pollution Discharge Elimination System Requirements for Stormwater Discharges Associated with Construction Activity (40 CFR Parts 122, 123, 124, implemented by State Water Resources Control Board Order No. 92-08 DWQ)
- National Emissions Standards for Hazardous Air Pollutants (42USC 7401-7671, 40 CFR 61, Subparts H & M)
- Federal Facilities Compliance Act of 1992 (PL 102-386)
- Occupational Radiation Protection (10 CFR 835)
- Radioactive Waste Management (DOE Order 435.1)
- Radiation Protection of the Public and the Environment (DOE Order 5400.5)
- Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978(40 CFR 204, 205, 211)
- Standards for Protection Against Radiation (10 CFR 20)
- Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR 61)

State and Local Requirements

- Yolo-Solano Air Quality Management District Rules and Regulations, Rule 2.3, Ringlemann Chart
- Prohibited Acts, Health and Safety Code, Chapter 3, Emissions Limitations Environment (California Health and Safety Code §41700)
- Control of Radioactive Contamination in the Environment (California Health and Safety Code, §114705, et seq.)
- Radiation Control Law (California Health and Safety Code, §14960, et seq.)
- State Department of Health Service Radiation Regulations (17 CCR, Chapter 5, Subchapter 4, § 30100, et seq.)

4.3 Risk-Based Requirements

As specified in 40 CFR Section 300.430, the acceptable human exposure to carcinogens at CERCLA sites is an excess upper bound lifetime cancer risk between 10^{-4} and 10^{-6}. Furthermore, in situations involving radionuclides, EPA states that a specific risk estimate of 1 in 10,000 to 1 in 1,000,000, around 10^{-4} may be considered acceptable if justified based on site-specific conditions (EPA, 1997). For systemic non-carcinogen toxicants, this regulation specifies that acceptable exposure shall result in a no-adverse-effect during a lifetime, which is measured using a hazard index (HI) of less than 1.0.

4.4 Other Pertinent Factors for Determining Removal Action Objectives—Memorandum of Agreement

In addition to ARARs and the human and ecological risk evaluation data, the MOA signed between UC Davis and DOE was considered in the development of RAOs. The MOA requires that DOE cleanup the WDPs and EDPs, excluding the UC Davis landfill underlying the EDPs. The MOA also requires that the RAs be implemented in a manner that minimizes impact to Site university research.

4.5 Determination of Removal Action Objectives

The specific RAOs (developed from risk-based requirements, ARARs and other pertinent factors below) for the WDPs RA are:

- Mitigate potential excess cumulative cancer risk to an individual from exposure to Site contaminants to the nominal range of 10^{-4} to 10^{-6}, using 10^{-6} as the point of departure;
- Reduce potential non-cancer HIs to levels below 1;
- Mitigate present and potential future impact to ground water;
- Mitigate potential ecological risks during and after RA; and,
- Minimize impact to Site university research.

The specific RAOs developed from risk-based requirements, ARARs and other pertinent factors for the EDPs are the same as those for the WDPs with the following addition:

- Allow for future UC Davis remediation of underlying landfill.

As discussed in Section 3, these RAOs are already met for WDPs and EDPs soil; therefore RAs only need to address the WDPs and EDPs gravel, curbing and asphalt.

Table 4-1. Chemical-Specific Requirements for the LEHR Facility

Requirement/Authority	Comments	ARAR Category
Federal		
Solid Waste Disposal Act, Resource Conservation and Recovery Act, (42 USC §6921, 40 CFR Part 261)	Identification and listing of hazardous waste. If waste is listed in 40 CFR 261 or tested according to specified test methods or by applying knowledge of the hazardous characteristics of the waste, and the waste is determined to be hazardous, compliance with 40 CFR 262, Standards Applicable to Generators of Hazardous Waste, is required.	Applicable
Clean Water Act (33 USCA 1251-1376, 40 CFR 122, 125, 136)	Both on-site and off-site discharges from CERCLA sites to surface waters are required to meet substantive Clean Water Act limitations, monitoring requirements and best management practices.	Applicable
Safe Drinking Water Act (42 USCA 300 and 40 CFR 141.11-16, 141.50-51)	Establishes MCLs as health-based standards and MCLGs as health goals for public water supply systems. The LEHR site is not a public water supply system. However, this requirement is relevant and appropriate.	Relevant and Appropriate
Establishment of Cleanup Levels at CERCLA Sites with Radioactive Contamination (EPA, 1997, OSWER Directive No. 9200.4-18)	Cleanup should generally achieve a carcinogenic risk within the $1x10^{-4}$ to $1x10^{-6}$ range based on the reasonable maximum exposure for an individual. A specific risk estimate near $1x10^{-4}$ may be considered acceptable if justified based on site-specific conditions.	To Be Considered
Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination, 64 FR 234, Dec. 7, 1999	Provides screening values for surface soil contamination release levels and information on NRC dose modeling. Supplements the NRC Final Rule on Radiological Criteria for License Termination 62 FR 39058 July 21, 1997. Surface soil screening values equivalent to 25 mrem/y are provided for Strontium-90 and Radium-226.	To Be Considered
State and Local		
Criteria for Identifying Hazardous Wastes (CCR, Title 22, 66261. 21–33)	Tests for identifying hazardous characteristics are set forth in these regulations. If a chemical is either listed or tested and found hazardous, then remedial actions must comply with those CCR, Title 22 requirements.	Applicable

Table 4-1. Chemical-Specific Requirements for the LEHR Facility (continued)

Requirement/Authority	Comments	ARAR Category
Porter-Cologne Water Quality Control Act (California Water Code, Div. 7, § 13000, et. seq. and 23 CCR Chap. 15, 2510-2559, 2580-2601)	Establishes authority for state and regional water boards to determine site-specific waste discharge requirements and to regulate disposal of waste to land. Contains corrective action requirements stating that a COC not exceed background values unless it is technically or economically infeasible, in which case the default clean-up values would be the Basin Plan Water Quality Objectives.	Applicable
Central Valley Regional Water Quality Control Board Basin Plan, "Policy for Investigation and Cleanup of Contaminated Sites" and "Policy for Application of Water Quality Objectives"	Describes water basins in the Central Valley Region, establishes beneficial uses of ground and surface waters, establishes water quality objectives and numerical standards, establishes implementation plans to meet water quality objectives and protect beneficial uses, and incorporates statewide water quality control plans and policies. Any activity, including, but not limited to, the discharge of contaminated soils or waters, or *in-situ* treatment or containment of contaminated soils or waters, must not result in actual water quality exceeding water quality objectives. The "Policy for Investigation and Cleanup of Contaminated Sites" establishes and describes policy for investigation and remediation of contaminated sites. Also includes implementation actions for setting ground water and soil cleanup levels. Cleanup levels for soils should be equal to levels that would achieve background concentrations in ground water unless such levels are technically and economically infeasible to achieve. In such cases, soil cleanup levels are such that ground water will not exceed applicable ground water quality objectives. "Policy for Application of Water Quality Objectives" defines water quality objectives and explains how the Regional Water Board applies numerical and narrative water quality objectives to ensure the reasonable protection of beneficial uses of water and how the Regional Water Board applies Resolution No. 68-16 to promote the maintenance of existing high quality waters. Applies to all cleanups of discharges that may affect water quality.	Applicable

Table 4-1. Chemical-Specific Requirements for the LEHR Facility (continued)

Requirement/Authority	Comments	ARAR Category
State Water Resources Control Board Resolution No. 68-16, "Anti-degradation Policy"	Requires that high quality surface and ground waters be maintained to the maximum extent possible. Degradation of waters will be allowed (or allowed to remain) only if it is consistent with the maximum benefit to the people of the State, does not unreasonably affect present and anticipated beneficial uses, and does not result in water quality less than that prescribed in RWQCB and SWRCB policies, as defined by the substantive requirements. If degradation is allowed, the discharge must meet best practicable treatment or control, which must prevent pollution or nuisance and result in the highest water quality consistent with maximum benefit to the people of the state.	Applicable
State Water Resources Control Board Resolution No. 92-49 (as amended April 21, 1994)	Establishes requirements for investigation and cleanup and abatement of discharges. Among other requirements, dischargers must clean up and abate the effects of discharges in a manner that promotes the attainment of either background water quality, or the best water quality that is reasonable if background water quality cannot be restored. Requires the application of Title 23, CCR, Section 2550.4, requirements to cleanups.	Relevant and Appropriate[1]
State Water Resources Control Board Resolution No. 88-63, "Sources of Drinking Water Policy"	Specifies that, with certain exceptions, all ground and surface water have the beneficial use of municipal or domestic water supply. Applies in determining beneficial uses for water that may be affected by discharges of waste. SWRCB Resolution 88-63 applies to all sites that may be affected by discharges of waste to ground water or surface water. The resolution specifies that, with certain exceptions, all ground water and surface water have the beneficial use of municipal use or domestic supply. Consequently, California State primary MCLs are relevant and appropriate; however, the most stringent federal or state standard will be the ARAR for the removal action.	Applicable

Table 4-1. Chemical-Specific Requirements for the LEHR Facility (continued)

Notes:

1 The following standard is set forth in Title 22 CCR section 66264.94, Title 22 CCR section 66265.94, Title 23 CCR section 2550.4, and SWRCB Res. No. 92-49 section IIIG: "Concentration limits for a constituent of concern greater than background values for that constituent can be established only if it is demonstrated that it is technologically or economically possible to achieve the background value for that constituent; in no event shall a concentration limit greater than background for a constituent of concern exceed the lowest concentration that is technologically or economically achievable." The U.S. Department of Energy reserves their position that this standard is a Federal ARAR via its incorporation in Title 22 CCR section 66264.94 which was federally authorized via EPA's authorization of the State of California RCRA program.

Abbreviations and Acronyms:

ARAR	Applicable or Relevant and Appropriate Requirement
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act of 1980
COC	Chemical of Concern
EPA	U.S. Environmental Protection Agency
FR	Federal Register
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
mrem/y	millirem per year
NRC	Nuclear Regulatory Commission
RCRA	Resource Conservation and Recovery Act
RWQCB	Regional Water Quality Control Board
SWRCB	State Water Resources Control Board

Table 4-2. Location-Specific Requirements for the LEHR Facility

Requirement/Authority	Comments	ARAR Category
Federal		
Endangered Species Act of 1973 (16 USC § 1531 et seq., 50 CFR Parts 10, 11, 17, 200, 402, & 424, and 40 CFR 257.3)	Facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. Activities will be evaluated to determine their impact on listed species and species proposed for listing and their habitat. If jeopardy or adverse modification will result from any site activities, a determination will be made based on a consultation with US Fish and Wildlife Service (USFWS) regarding the need for mitigation measures and/or an incidental take statement. Specific mitigation measures will be identified and implemented per USFWS guidelines.	Applicable
Executive Order 11988 (floodplain management) and 11990 (protection of wetlands) (40 CFR 6, 10 CFR 1022)	Directs all Federal agencies to avoid, if possible, development and other activities in the 100-year base floodplain. Where the base floodplain cannot be avoided, special considerations and studies for new facilities and structures are needed. Design and siting are to be based on scientific, engineering, and architectural studies; consideration of human life, natural processes, and cultural resources; and the planned lifespan of the project. Federal agencies are required to: 1) reduce the risk of flood loss; 2) minimize the impact of floods on human safety, health, and welfare, and 3) restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibility. 44 Federal Register 12594 states that DOE can meet requirements of these Executive Orders through applicable DOE and NEPA procedures.	Applicable
National Historic Preservation Act of 1966 (16 USC 470 et seq., Public Law 89-665 and amendments of 1980, Public Law 96-515, 36 CFR 800)	Requires federal agencies to take into account the effects of their projects on historic properties listed, or eligible for listing, on the National Register of Historic Properties and to afford the Advisory Council a reasonable opportunity to comment on them.	Applicable
Fish and Wildlife Coordination Act (16 USC 661-666)	Requires action to preserve endangered species or threatened species. Prior to conducting any ground disturbing activities, surveys will be conducted for species of concern.	Applicable

Table 4-2. Location-Specific Requirements for the LEHR Facility (continued)

Requirement/Authority	Comments	ARAR Category
State And Local		
California Endangered Species Act (California Fish and Game Code, § 2050–2068)	Requires action to preserve endangered species or threatened species. Prior to conducting any ground-disturbing activities, surveys will be conducted for species of concern.	Applicable

Abbreviations:
NEPA National Environmental Policy Act
USFWS U.S. Fish and Wildlife Service

Table 4-3. Action-Specific Requirements for the LEHR Facility

Requirement	Comments	ARAR Category
Federal		
Clean Water Act § 404 (33USC 1344, 33CFR 328 and 40 CFR 230)	Establishes a national program to control the discharge of dredged or fill materials into "waters of the United States". "Waters of the US" is defined to include all tributaries of navigable waters and nearly all wetlands. Although no permit would be required for actions affecting a wetland, the substantive provisions of Section 404, including agency coordination prior to construction, state water quality certification, and possibly even mitigation for loss may be applicable. These requirements may apply if removal actions (RAs) cause turbid water to enter drainages, or if RAs impact wetlands adjacent to Putah Creek.	Applicable
National Pollution Discharge Elimination System (40 CFR Parts 122, 123, 124, implemented by State Water Resources Control Board Order No. 92-08 DWQ)	Regulates pollutants in discharge to storm water associated with construction activities (clearing, grubbing, or excavation) involving the disturbance of five acres or more. Ensures stormwater discharges do not contribute to a violation of surface water quality standards. Includes measures to minimize and/or eliminate pollutants in stormwater discharges and monitoring to demonstrate compliance. The Dog Pens RAs will not disturb five acres or more. However, this requirement is relevant and appropriate.	Relevant and Appropriate
National Emissions Standards for Hazardous Air Pollutants (42USC 7401-7671, 40 CFR 61, Subparts H)	Emissions of radionuclides from any U.S. Department of Energy (DOE) facility to the ambient air shall not exceed levels that would result in an effective dose equivalent of 10 millirem per year (mrem/yr). Dust generated from excavation activities would be subject to this requirement.	Applicable
Federal Facilities Compliance Act of 1992, (PL 102-386)	This act amends the Solid Waste Disposal Act and states that all federal agencies are subject to all substantive and procedural requirements of federal, state, and local solid and hazardous waste laws in the same manner as any private party.	Applicable
10 CFR 835 Occupation Radiation Protection	Provides for the protection of radiation workers at DOE facilities. Includes dose limits and requirements to reduce the dose to levels that are ALARA.	Applicable
Radioactive Waste Management (DOE Order 435.1)	Specifies requirements for managing DOE radioactive waste, including off-site disposal requirements for radioactive waste shipped to commercial facilities. Although not promulgated standards, these requirements constitute requirements for protection of the public with which the proposed action would comply.	Applicable

Table 4-3. Action-Specific Requirements for the LEHR Facility (continued)

Requirement	Comments	ARAR Category
Radiation Protection of the Public and the Environment (DOE Order 5400.5)	This Order establishes requirements for DOE facilities and operations for control of radiation exposure to the public. Although not promulgated standards, the DOE Order requirements were developed for protection of the public and the environment and are mandatory requirements for DOE activities. Chapter I adopts the International Commission on Radiological Protection recommendation that radiation dose to individuals be based on consideration of levels that are ALARA. Chapter II establishes DOE public dose limit for all exposure modes and DOE sources of radiation of 100 mrem/yr effective dose equivalent. The public dose limit specifically applies to remedial actions. This radiation dose limit also forms the basis for the release of radionuclides to the environment and the release of properties for unrestricted use discussed in Chapter IV.	Applicable
Noise Control Act of 1972, as amended by the Quiet Communities Act of 1978 (40 CFR 204, 205, 211)	Construction and transportation equipment noise levels (e.g., portable air compressors, and medium and heavy trucks), process equipment noise levels, and noise levels at the property boundaries of the project are regulated under this Act. State or local agencies typically enforce these levels.	Applicable
Standards for Protection Against Radiation (10 CFR 20. Subparts B, C & E))	DOE activities conducted at the Laboratory for Energy-Related Health Research are not subject to the Nuclear Regulatory Commission's (NRC) licensing requirements. However, DOE policy articulated in DOE Order 5400.5 is to adopt and implement standards generally consistent with those of the NRC for DOE facilities and activities not subject to licensing authority. The NRC Standards for radiation protection and occupational exposure dose limits are in Subparts B & C. Subpart E defines radiological criteria for unrestricted use of sites with residual radioactivity.	Relevant and Appropriate
Licensing Requirements for Land Disposal of Radioactive Waste (10 CFR 61)	Establishes requirements for radiation protection, access restrictions, future impacts, siting, drainage, final cover, buffer zones, ground water monitoring and waste disposal requirements.	Relevant and Appropriate

Table 4-3. Action-Specific Requirements for the LEHR Facility (continued)

Requirement	Comments	ARAR Category
State and Local		
Yolo-Solano Air Quality Management District Rules and Regulations, Rule 2.3, Ringlemann Chart	Establishes a permissible limit on visible emissions (Ringlemann Chart) resulting from construction activities, such as soil disturbance during a RA.	Applicable
Prohibited Acts (Health and Safety Code § 41700)	Prevents discharge of pollutants into the air that will cause injury, detriment, nuisance, or annoyance to any considerable number of persons or the public. Regulation applicable to construction activities during RA.	Applicable
Control of Radioactive Contamination in the Environment (California Health and Safety Code, § 114705, et. seq.)	Details administration of programs of surveillance and control of those activities that could lead to the introduction of radioactive materials into the environment. Applicable unless activity is governed by DOE statutory authority.	Applicable
Radiation Control Law (California Health and Safety Code, § 114960, et. seq.)	Institutes and maintains a regulatory program for sources of ionizing radiation so as to provide for compatibility with standards and regulatory programs of the federal government and an integrated system within the state. Applicable unless activity is governed by DOE statutory authority.	Applicable
State Department of Health Service Radiation Regulations (17 CCR, Chapter 5, Subchapter 4, § 30100, et. seq.)	Presents regulations of the Department of Health Services pertaining to radiation such as standards for protection against radiation, low-level radioactive waste disposal, and transportation regulations. Applicable unless activity is governed by DOE statutory authority or regulation.	Applicable

Abbreviations and Acronyms:

ALARA	As-Low-As-Reasonably-Achievable
ARAR	Applicable or Relevant and Appropriate Requirement
DOE	U.S. Department of Energy
LEHR	Laboratory for Energy-Related Health Research
mrem/yr	millirem per year
NRC	Nuclear Regulatory Commission
RA	Removal Action

5. IDENTIFICATION AND EVALUATION OF REMOVAL ACTION ALTERNATIVES

In accordance with the "Guidance on Conducting Non-Time Critical RAs" (EPA, 1993), the following steps were followed to develop and evaluate RA alternatives for the WDPs and EDPs:

1. Potentially applicable remedial technologies were identified and screened based on effectiveness, implementability and cost;
2. Remedial technologies that passed the initial screening were developed into RA alternatives for each area;
3. Alternative evaluation criteria were defined; and,
4. Alternatives were evaluated on effectiveness, implementability and cost.

5.1 Remedial Technology Evaluation

Remedial technologies with the potential to achieve RAOs were screened according to their effectiveness, implementability and cost as shown in Table 5-1. Only proven technologies known to be applicable for the WDPs and EDPs were retained for RA alternative development.

The screening process indicated that only a limited number of remedial technologies are suitable for the Dog Pens. These include:

- Institutional controls (includes legal controls, contaminant monitoring, administrative monitoring and physical controls);
- Excavation;
- Waste segregation; and,
- Waste disposal (includes low-level and sanitary waste disposal).

Although deemed effective in restricting contaminant mobility, the cap and landfill technologies were not retained due to their potential land-use impacts. Natural attenuation and permeable surfacing were not considered viable technologies, as they may not protect soil and ground water from potential future impacts.

5.2 Development and Description of Removal Action Alternatives

Remedial technologies were developed into RA alternatives for each area (Table 5-2). In accordance with CERCLA and NEPA requirements, a No Action alternative was also retained for evaluation.

Three alternatives were developed for the WDPs:

- Alternative 1: No Action;
- Alternative 2: Implement institutional controls; and,
- Alternative 3: Remove and dispose gravel, concrete curbs and asphalt.

Four alternatives were developed for the EDPs:

- Alternative 1: No Action;
- Alternative 2: Implement institutional controls;
- Alternative 3: Remove and dispose concrete curbs; and,
- Alternative 4: Remove and dispose gravel, concrete curbs and asphalt.

The alternatives were evaluated according to the criteria described below.

5.3 Evaluation Criteria

According to EPA guidance, the alternatives were evaluated for cost, effectiveness and implementability. During this evaluation, the alternatives were reviewed against specific criteria, as recommended by CERCLA and EPA guidance.

Effectiveness was evaluated according to the following criteria:

- Overall Protection of Public Health and the Environment—Assesses the degree to which public health and the environment is protected.
- Compliance with ARARs—Determines whether the alternative meets ARARs as described in Section 4, and if any waivers of these requirements are necessary.
- Long-Term Effectiveness—Evaluates the degree of permanence and certainty that the proposed alternative will be successful.
- Reduction in Toxicity, Mobility, or Volume through Treatment—Assesses the degree to which an alternative can reduce the toxicity, mobility or volume of contamination through treatment.
- Short-Term Effectiveness—Assesses the immediate threats to the surrounding community and Site workers during implementation of the alternative.

Implementability was evaluated according to the following criteria:

- Technical Feasibility—Evaluates whether the remedial technology will be a technically reliable remedy.
- Administrative Feasibility—Assesses the degree of difficulty of obtaining the necessary permits or regulatory approvals for the alternative.
- Availability of Services—Assesses the degree of difficulty of obtaining necessary products or services needed to complete the RA.
- Regulatory Acceptance—Evaluates the likelihood of an alternative being accepted by the regulatory agencies.
- Community Acceptance—Evaluates the likelihood of an alternative being accepted by the local community.

Cost estimate summaries for each alternative are presented in Appendix A, Cost Estimate Summaries for Removal Action Alternatives. Costs were developed for the following categories, as applicable:

- Direct Capital Costs—Includes costs for field labor, equipment and material. Subcontracted tasks supporting field activities (i.e., analytical lab services and land surveyors) are also included.
- Indirect Capital Costs—Includes costs for project management, permitting, engineering and design.
- Annual Costs—Covers long-term costs associated with implementing no action and institutional controls.

5.4 Evaluation of Alternatives for the Western Dog Pens

Three alternatives were developed and evaluated for the WDPs: 1) no action, 2) implement institutional controls and 3) remove and dispose gravel, concrete curbs and asphalt. Each of these alternatives was evaluated according to the criteria described above and summarized in Table 5-3.

5.4.1 Alternative 1—No Action

As required by NCP guidance, a No Action alternative was developed to determine the potential effects and costs associated with leaving contaminants in-place. The No Action alternative includes inspecting the Site as it is currently without any further environmental restoration. Site inspections would be conducted on a semi-annual basis to document the condition of the Site. However, legal, administrative and physical controls would not be applied to control site access and limit contaminant migration. Although radionuclides will remain in the curbs and gravel for more than 1,000 years, a 100-year period was considered reasonable for costing purposes. Table 5-3 summarizes Alternative 1 according to effectiveness, implementability and cost as described below.

5.4.1.1 Effectiveness

Residual levels of radionuclides will remain in the WDPs for more than 1,000 years beyond the 100-year time period established for this alternative. Potential future exposure to the public and the environment is not prevented under this alternative, as there is no action taken to restrict access or control contaminant migration. However, short-term impacts are unlikely if the Site remains in its current state of use and management because access is limited to UC Davis employees and researchers. ARARs for surface water quality, water discharge and radioactive materials may not be met under Alternative 1.

5.4.1.2 Implementability

This alternative is implementable, as site inspections are routinely conducted at the Site. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis.

5.4.1.3 Cost

The total estimated present-worth cost of Alternative 1 is $149,000 and consists of capital costs for work plan preparation and project management, and annual costs for conducting semi-annual site inspections for 100 years.

5.4.2 Alternative 2—Implement Institutional Controls

Similar to Alternative 1, this alternative includes semi-annual site inspections and does not involve environmental restoration. However, institutional controls are added to limit exposure to the public and the environment. These controls include:

- Perimeter fences to prevent public access to impacted areas;
- Permanent postings to prevent unsupervised subsurface soil disturbance;
- Site monitoring to verify that contaminants have not migrated, and that the Site remains in a safe and stable condition; and,
- Enforcement of land use restrictions to control access.

As in the case of Alternative 1, a 100-year period was used for costing purposes. Table 5-3 summarizes Alternative 2 by effectiveness, implementability and cost, as described below.

5.4.2.1 Effectiveness

Residual levels of radionuclides will remain in the WDPs for more than 1,000 years beyond the 100-year time period established for this alternative. Potential future exposure to the public and the environment is possible, but not likely, under this alternative if site controls are maintained. The enforcement of land use restrictions would limit land use as long as contaminants are present. Alternative 2 meets all ARARs.

5.4.2.2 Implementability

This alternative is implementable, as site inspections and maintenance are routinely conducted at the Site. Land use restrictions and site postings are also easily implemented. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis. Long-term enforcement of institutional controls would require vigilance from local regulatory bodies.

5.4.2.3 Cost

The total estimated present-worth cost of Alternative 2 is $332,000, and consists of capital costs for work plan preparation, implementation of land use restrictions, fence installation and project management, and annual costs for conducting periodic site maintenance and semi-annual site monitoring for 100 years.

5.4.3 Alternative 3—Remove and Dispose Gravel, Concrete Curbs and Asphalt

Under this alternative, all gravel, concrete curbs and asphalt would be delineated, characterized, excavated, segregated and disposed. Following waste removal, confirmation samples will be collected for Ra-226, Sr-90 and chlordane analyses based on an approved statistical-based sampling plan. The following assumptions apply:

- Standard construction equipment is used;
- The excavation limits and the locations of confirmation samples are documented on a land survey after all waste is removed;
- Excavations are backfilled and compacted with clean fill material from an off-site source that is known to be uncontaminated;
- Existing features (i.e., fences, trees, monitoring wells, structures and underground utilities) are protected during the RA or restored to their original condition at the end of the RA;
- LEHR standard procedures (i.e., Standard Operating Procedures [SOPs], Health and Safety Procedures [HSPs], Standard Quality Procedures [SQPs]) are followed during all RA activities;
- Gamma spectroscopy and other high-resolution detectors are used in the field to delineate radiologically-impacted concrete;
- Composite samples are collected (either before or after waste removal) to characterize low-level waste and potentially releasable material (per DOE Order 5400.5 and NCRP Report No. 116);
- No hazardous or mixed waste is generated;

- Regulatory approval is granted for disposition of releasable material at a sanitary landfill;
- All waste is disposed at EPA-approved facilities;
- Waste is either pre-characterized and direct-loaded into re-usable containers for immediate disposal or stockpiled and managed pending characterization; and,
- Confirmation sample locations will be based on a random grid generated with the statistical system used in previous LEHR RAs.
- Institutional controls will be applied if confirmatory samples indicate unacceptable residual risk for unrestricted land use.
- Land use covenants will be required in accordance with applicable statutes and regulations if future risk assessment indicates a need for them.

Table 5-3 summarizes Alternative 3 effectiveness, implementability and cost, as described below.

5.4.3.1 Effectiveness

Public and environmental exposure to contaminants is improbable in the long term, because all contaminants exceeding 10^{-6} risk would be removed and disposed in an engineered facility. During the RA, exposure to contamination would be mitigated by the application of administrative and engineering controls. There are transportation risks associated with off-site shipment of waste material, including potential fatalities due to truck or train accidents (see Section 8 for details). Statistically, these risks exceed the risk reduction gained by removing the material from the Site.

5.4.3.2 Implementability

This alternative is technically feasible (Figure A-1). No significant administrative barriers are expected and necessary equipment, supplies and personnel should be readily available.

5.4.3.3 Cost

The total estimated present-worth cost of Alternative 3 is $2,800,000, which includes capital costs for work planning, site preparation, waste removal, field sampling, field and laboratory analyses, waste disposal, site restoration, reporting, engineering, permitting, and project management.

5.5 Evaluation of Alternatives for the Eastern Dog Pens

Four alternatives were developed for the EDPs: 1) No Action, 2) implement institutional controls, 3) remove and dispose concrete curbs and 4) remove and dispose gravel, concrete curbs and asphalt.

5.5.1 Alternative 1—No Action

This alternative is similar to the WDPs No Action alternative described in Section 5.4.1. However, its timeframe is expected to be limited to five years because the UC Davis landfill underlying the EDPs will likely be remediated. This alternative includes inspecting the Site as it is currently without any further environmental restoration. Site inspections would be conducted on a semi-annual basis to document the condition of the Site. However, legal, administrative and physical controls would not be applied to control site access and limit contaminant migration. Following five years of site inspections, it is assumed that the contaminants will be either stabilized with the landfill waste under an engineered cap or disposed off-site according to the Record of Decision. Table 5-4 summarizes Alternative 1 effectiveness, implementability and cost, as discussed below.

5.5.1.1 Effectiveness

Residual levels of radionuclides will remain in the EDPs for more than 1,000 years. Potential future exposure to the public and the environment are not prevented under this alternative, as there is no action taken to control contaminant migration. However, contaminant migration is unlikely, since it is assumed that the landfill underlying this area will be remediated. ARARs for surface water quality, water discharge and radioactive materials will likely be met if the landfill is capped.

5.5.1.2 Implementability

This alternative is implementable, as site inspections are routinely conducted at the Site. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis. DOE and UC Davis will need to reach an agreement on DOE's responsibilities to support the final joint remedy of the Eastern Dog Pens and the underlying landfill. Further action may be required depending on the final remedy for the underlying landfill.

5.5.1.3 Cost

The total estimated present-worth cost of Alternative 1 is $48,000, and consists of capital costs for work plan preparation and project management, and annual costs for conducting semi-annual site inspections for five years.

5.5.2 Alternative 2—Implement Institutional Controls

This alternative also includes semi-annual site inspections and does not involve environmental restoration. However, institutional controls are added to limit the potential for contaminant releases that would result in exposure to the public and the environment. These controls include:

- Perimeter fences to prevent public access to impacted areas;
- Permanent postings to prevent unsupervised subsurface soil disturbance;

- Site monitoring to verify that contaminants have not migrated, and that the Site remains in a safe and stable condition; and,
- Enforcement of land use restrictions to control access.

As in the case of Alternative 1, a five-year period was used for costing purposes. Table 5-4 summarizes Alternative 2 by effectiveness, implementability and cost, as described below.

5.5.2.1 Effectiveness

As for the WDPs, residual levels of radionuclides would remain in the EDPs for more than 1,000 years if no action were taken. However, assuming that the underlying landfill is remediated, institutional controls should adequately protect the public and the environment. The enforcement of land use restrictions would limit exposure pending remediation of the underlying landfill. Alternative 2 meets all ARARs.

5.5.2.2 Implementability

This alternative is implementable, as site inspections and maintenance are routinely conducted at the Site. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis. DOE and UC Davis will need to reach an agreement on DOE's responsibilities to support the final joint remedy of the Eastern Dog Pens and the underlying landfill. Further action may be required depending on the final remedy for the underlying landfill. Long-term enforcement of institutional controls would require vigilance from local regulatory bodies.

5.5.2.3 Cost

The total estimated present-worth cost of Alternative 2 is $167,000 and consists of capital costs for work plan preparation, implementation of land use restrictions, fence installation and project management, and annual costs for conducting periodic site maintenance and semi-annual site inspections for five years.

5.5.3 Alternative 3—Remove and Dispose Concrete Curbs

According to the data collected during prior investigations, it is assumed that the EDPs gravel and asphalt do not pose an exposure threat and that leaving this material would not hinder the effort to cap the underlying landfill, as it can be easily graded and compacted. However, to further facilitate remediation of the landfill, the concrete curbing should be removed, as it is not easily compacted and may contribute to differential settlement under the landfill cap.

Under this alternative, the perimeter fence would be replaced and the concrete curbing would be delineated, characterized, excavated, segregated and disposed. Following concrete removal, it is assumed that the Site would be stabilized and monitored semi-annually for five years until the landfill remediation is complete. The following assumptions apply:

- Standard construction equipment is used;
- Existing features (i.e., fences, trees, monitoring wells, structures and underground utilities) are protected during the RA or restored to their original condition at the end of the RA;
- LEHR standard procedures (i.e., SOPs, HSPs, SQPs) are followed during all RA activities;
- Gamma spectroscopy and other high-resolution detectors are used in the field to delineate radiologically-impacted concrete;
- Composite samples are collected (either before or after waste removal) to characterize low-level waste and potentially releasable material (per DOE Order 5400.5 and NCRP Report No. 116);
- No hazardous or mixed waste is generated;
- Regulatory approval is granted for disposition of releasable material at a sanitary landfill;
- All waste is disposed at EPA-approved facilities; and,
- Waste is either pre-characterized and direct-loaded into re-usable containers for immediate disposal or stockpiled and managed pending characterization.
- Land use covenants will be required in accordance with applicable statutes and regulations if future risk assessment indicates a need for them.

Table 5-4 summarizes Alternative 3 effectiveness, implementability and cost, as discussed below.

5.5.3.1 Effectiveness

The greatest potential for human and environmental exposure to residual concentrations of contaminants would occur when the concrete curbing is being removed. However, impacts would be mitigated through the use of administrative and engineering controls. This alternative complies with all applicable ARARs. Available data suggest that the residual contamination in the remaining gravel and asphalt are minor, and would therefore not impact human health or the environment. There are transportation risks associated with off-site shipment of waste material, including potential fatalities due to truck or train accidents. Statistically, these risks exceed the risk reduction gained by removing the material from the Site.

5.5.3.2 Implementability

Most of the RA is technically feasible (Figure A-2). Field radiological surveys may be difficult due the presence of gravel and uneven terrain. Resulting waste segregation errors may increase the volume of low-level waste disposed. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis.

5.5.3.3 Cost

The total estimated present-worth cost of Alternative 3 is $883,000 and includes capital costs for work planning, site preparation, waste removal, field sampling, field and laboratory analyses, waste disposal, site restoration, reporting, engineering, permitting and project management. Annual costs for inspection, maintenance and management are provided for the estimated five years between the RA and the remediation of the underlying landfill.

5.5.4 Alternative 4—Remove and Dispose Gravel, Concrete Curbs and Asphalt

This alternative is similar to the WDPs Alternative 3 discussed in Section 5.4.3. Under this alternative, waste would be radiologically delineated, characterized, excavated, segregated and disposed. Following waste removal, confirmation samples would be collected for Ra-226, Sr-90, chlordane and dieldrin analyses based on an approved statistical-based sampling plan. The Site will then be restored to facilitate remediation of the underlying landfill. The following assumptions apply:

- Standard construction equipment is used;
- The excavation limits and the locations of confirmation samples are documented on a land survey after all waste is removed;
- Excavations are backfilled and compacted with clean fill material from an off-site source that is known to be uncontaminated;
- Existing features (i.e., fences, trees, monitoring wells, structures and underground utilities) are protected during the RA or restored to their original condition at the end of the RA;
- LEHR standard procedures (i.e., SOPs, HSPs, SQPs) are followed during all RA activities;
- Gamma spectroscopy and other high-resolution detectors are used in the field to delineate radiologically-impacted concrete;
- Composite samples are collected (either before or after waste removal) to characterize low-level waste and potentially releasable material (per DOE Order 5400.5 and NCRP Report No. 116);
- No hazardous or mixed waste is generated;
- Regulatory approval is granted for disposition of releasable material at a sanitary landfill;
- All waste is disposed at EPA-approved facilities;
- Waste is either pre-characterized and direct-loaded into re-usable containers for immediate disposal or stockpiled and managed pending characterization; and,

- Confirmation sample locations will be based on a random grid generated with the statistical system used in previous LEHR RAs.
- Land use covenants will be required in accordance with applicable statutes and regulations if future risk assessment indicates a need for them.

Table 5-4 summarizes Alternative 4 effectiveness; implementability and cost, as discussed below.

5.5.4.1 Effectiveness

As for the WDPs Alternative 3, public and environmental exposure to contaminants is improbable in the long term, because all contaminants associated with the Dog Pens structures would be removed and disposed in an engineered facility. During the RA, the potential for human and environmental exposure is greater, but unlikely, due to the use of administrative and engineering controls. There are transportation risks associated with off-site shipment of waste material, including potential fatalities due to truck or train accidents. Statistically, these risks exceed the risk reduction gained by removing the material from the Site.

5.5.4.2 Implementability

The Alternative 4 RA is implementable (Figure A-3), although it may be difficult to differentiate between EDPs and underlying landfill waste. It may also be difficult to remove EDPs waste without disturbing or removing landfill waste.

5.5.4.3 Cost

The total estimated present-worth cost of Alternative 4 is $1,186,000, which includes capital costs for work planning, site preparation, waste removal, field sampling, field and laboratory analyses, waste disposal, site restoration, reporting, engineering, permitting, and project management.

Table 5-1. Remedial Technology Screening Summary

Technology	Description	Effectiveness	Implementability	Cost	Screening Status/ Comments
No Action	Continue to maintain the site without further remedial action.	Moderate	High	Low	Retained per National Contingency Plan guidance.
Natural Attenuation	Use natural site conditions to degrade and/or restrict movement of contaminants.	Low	High	Low	Not retained. The decay time for radioactive isotopes to reach acceptable risk levels would likely exceed 1,000 years. Natural site conditions are likely inadequate for restricting contaminant mobility.
Legal Controls	Limit future development and site use through deed restrictions.	Moderate	High	Moderate	Retained. Requires long-term enforcement, but effective for preventing human exposure to contaminants by limiting land use and site disturbance from excavation or other construction activities.
Contaminant Monitoring	Monitor contaminant levels, radiation levels and dust/contaminant migration.	High	High	Moderate	Retained. Necessary for documenting changing conditions and ensuring containment.
Administrative Monitoring	Ensure institutional controls are maintained and site use is controlled.	High	High	Low	Retained. Required to ensure continued use of institutional controls.

Table 5-1. Remedial Technology Screening Summary (continued)

Technology	Description	Effectiveness	Implementability	Cost	Screening Status/ Comments
Physical Controls	Install perimeter fence to restrict access and prevent exposure.	High	High	Low	Retained. Limits human access and exposure that may result from site disturbance. Effectiveness depends on the rigor of site monitoring and maintenance.
Permeable Surfacing	Place soil, gravel or pavement to function as a barrier to prevent human exposure to underlying soils.	Low/Moderate	High	Moderate	Not retained. Protects against above-surface exposure only; does not restrict subsurface contaminant mobility.
Excavation	Remove all or part of contaminated gravel, concrete and asphalt.	High	High	Moderate	Retained. Contaminants are physically removed, which eliminates further migration through soil. Dust control is required during this activity to prevent airborne migration.
Waste Segregation	Physically segregate excavated waste by waste stream prior to disposal.	High	High	Low	Retained. Waste is categorized for efficient handling and disposal. Effectiveness and implementability depend on the accuracy of the waste characterization.

Table 5-1. Remedial Technology Screening Summary (continued)

Technology	Description	Effectiveness	Implementability	Cost	Screening Status/ Comments
LLW Disposal	Dispose waste at a DOE-approved LLW disposal facility.	High	High	Moderate/High	Retained. Although expensive to ship and dispose, radionuclide mobility is restricted through disposal in an engineered facility.
Sanitary Waste Disposal	Dispose waste at a licensed and permitted sanitary landfill.	High	High	Moderate	Retained. Sanitary waste can be disposed locally at a moderate expense
Cap	Consolidate waste and engineer an on-site RCRA cap to contain contaminants.	High	Low/Moderate	Moderate/High	Not retained. Effective because mobility is limited through disposal in an engineered facility. Restricts land use.
Landfill	Construct a new RCRA landfill for waste disposal.	High	Low	High	Not retained. Effective because mobility is limited through disposal in an engineered facility. However, implementation is unlikely due to the lengthy design and permitting process that would be required.

Abbreviations:
DOE U.S. Department of Energy
LLW Low-Level Waste
RCRA Resource Conservation and Recovery Act

Table 5-2. Selected Remedial Technologies and Alternatives

Area	Retained Remedial Technologies	Alternative
Western Dog Pens	No Action	No Action
	Legal controls, contaminant monitoring, administrative monitoring, and physical controls	Implement institutional controls
	Excavation, waste segregation, low-level waste disposal, and sanitary waste disposal	Remove gravel, concrete curbs and asphalt
Eastern Dog Pens	No Action	No Action
	Legal controls, contaminant monitoring, administrative monitoring, and physical controls	Implement institutional controls
	Excavation, waste segregation, low-level waste disposal, sanitary waste disposal, legal controls, contaminant monitoring, administrative monitoring, and physical control	Remove concrete curbs
	Excavation, waste segregation, low-level waste disposal, and sanitary waste disposal	Remove gravel, concrete curbs and asphalt

Table 5-3. Evaluation Summary for Western Dog Pens Alternatives

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Implement institutional controls	Alternative 3: Remove and dispose gravel, concrete curbs and asphalt
EFFECTIVENESS			
Overall Protection of Public Health and the Environment	Potential future impacts to human health and the environment are not prevented.	Residual contamination may remain in the curbs and gravel for more than 1,000 years. Site controls should be maintained indefinitely to prevent future human health and environmental/ecological impacts.	The majority, if not all, of the contaminants will be removed and disposed in an engineered disposal facility that will protect public health and the environment.
Compliance with ARARs	ARARs for surface water quality, water discharge requirements and release criteria for radioactive materials may not be met.	Meets all ARARs.	Meets all ARARs.
Long-Term Effectiveness	Impacts to the public, site workers and the environment are more probable if no action is taken to control contaminant migration.	Residual concentrations of contaminants require the use of institutional controls, which limit land use.	No restrictions to future land use are anticipated.
Reduction of Toxicity, Mobility or Volume Through Treatment	No active reduction of toxicity, mobility or volume.	No active reduction of toxicity, mobility or volume.	Removal of contaminated gravel/concrete/curbs will reduce contaminant mobility.
Short-Term Effectiveness	Impacts to the public, site workers and the environment are unlikely in the near future if the site remains in its current state of use and management.	Impacts to the public, site workers and the environment are unlikely in the near future if the site remains in its current state of use and management.	Administrative and engineering controls used during removal will mitigate impacts to the public, site workers and the environment.

Table 5-3. Evaluation Summary for Western Dog Pens Alternatives (continued)

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Implement institutional controls	Alternative 3: Remove and dispose gravel, concrete curbs and asphalt
IMPLEMENTABILITY			
Technical Feasibility	Periodic site inspections are technically feasible and implementable.	Periodic site inspections and maintenance are technically feasible and implementable.	The removal action is technically feasible and implementable.
Administrative Feasibility	No administrative barriers are expected; implementable. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis.	No administrative barriers are expected; implementable. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis.	No administrative barriers are expected; easily implemented.
Availability of Services and Materials	Inspection personnel are available.	Inspection personnel and maintenance supplies are available.	Field personnel, heavy equipment, supplies and specialized radiological monitoring equipment should be available.
Regulatory Acceptance	To be determined.	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.	To be determined.
COST			
Total Costs	$149,000	$332,000	$2,800,000

Abbreviation:
ARARs = Applicable or Relevant and Appropriate Requirements

Table 5-4. Evaluation Summary for Eastern Dog Pens Alternatives

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Implement institutional controls	Alternative 3: Remove and dispose concrete curbs	Alternative 4: Remove and dispose gravel, concrete curbs, and asphalt
EFFECTIVENESS				
Overall Protection of Public Health and the Environment	Potential future impacts to human health and the environment are not prevented.	Residual contamination may remain in the curbs and gravel for more than 1,000 years. Site controls should be maintained until contaminants are stabilized during the remediation of the underlying landfill.	The potential for exposure to low concentrations of contamination is reduced through the removal of curbs. Following remediation of the underlying landfill, the majority, if not all, of the contaminants will be contained in an engineered facility that will protect public health and the environment.	The majority, if not all, of the contaminants will be removed and contained in an off-site engineered facility that will protect public health and the environment.
Compliance with ARARs	ARARs for surface water quality, water discharge requirements and release criteria for radioactive materials may not be met.	Meets all ARARs.	Meets all ARARs.	Meets all ARARs.
Long-Term Effectiveness	Impacts to the public, site workers, and the environment are more probable if no action is taken to control contaminant migration.	Residual concentrations of contaminants require the use of institutional controls, which limit land use.	Restrictions on future land use depend on the remediation of the underlying landfill.	Restrictions on future land use depend on the remediation of the underlying landfill.
Reduction of Toxicity, Mobility or Volume Through Treatment	No active reduction of toxicity, mobility, or volume.	No active reduction of toxicity, mobility, or volume.	Removal and disposal of curbs will reduce contaminant mobility.	Removal and disposal of gravel, curbs and asphalt will reduce contaminant mobility.

Table 5-4. Evaluation Summary for Eastern Dog Pens Alternatives (continued)

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Implement institutional controls	Alternative 3: Remove and dispose concrete curbs	Alternative 4: Remove and dispose gravel, concrete curbs, and asphalt
Short-Term Effectiveness	Impacts to the public, site workers and the environment are unlikely in the near future if the site remains in its current state of use and management.	Impacts to the public, site workers and the environment are unlikely in the near future if the site remains in its current state of use and management.	Administrative and engineering controls used during removal will mitigate impacts to the public, site workers, and the environment.	Administrative and engineering controls used during removal will mitigate impacts to the public, site workers and the environment.
IMPLEMENTABILITY				
Technical Feasibility	Periodic site inspections are technically feasible and implementable. Feasibility depends on the selection of the final remedy for the underlying landfill.	Periodic site inspections and maintenance are technically feasible and implementable. Feasibility depends on the selection of the final remedy for the underlying landfill.	Most of the removal action is feasible and implementable. Radiological surveys may be challenging due to the presence of gravel and uneven terrain.	The removal action is implementable with some difficulty. Waste characterization and segregation may be challenging due to the proximity of waste in the underlying landfill.
Administrative Feasibility	No administrative barriers are expected; implementable. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis.	No administrative barriers are expected; implementable. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis.	Permitting may be required for Endangered Species Act compliance. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis.	Permitting may be required for Endangered Species Act compliance.
Availability of Services and Materials	Inspection personnel are available.	Inspection personnel and maintenance supplies are available.	Field personnel, heavy equipment, supplies, and specialized radiological monitoring equipment should be available.	Field personnel, heavy equipment, supplies, and specialized radiological monitoring equipment should be available.

Table 5-4. Evaluation Summary for Eastern Dog Pens Alternatives (continued)

Evaluation Criteria	Alternative 1: No Action	Alternative 2: Implement institutional controls	Alternative 3: Remove and dispose concrete curbs	Alternative 4: Remove and dispose gravel, concrete curbs, and asphalt
Regulatory Acceptance	To be determined.	To be determined.	To be determined.	To be determined.
Community Acceptance	To be determined.	To be determined.	To be determined.	To be determined.
COST				
Total Costs	$48,000	$167,000	$883,000	$1,186,000

6. COMPARATIVE EVALUATION OF ALTERNATIVES

The WDPs and EDPs alternatives were compared according to their effectiveness, implementability and cost. In this comparison, each of the evaluation criteria was considered relative to the other alternatives under evaluation.

6.1 Western Dog Pens Alternative Comparison

The WDPs Alternatives are compared below.

6.1.1 Effectiveness

Removal and disposal of gravel, concrete curbing and asphalt (Alternative 3) would be more effective than No Action (Alternative 1) or the implementation of institutional controls (Alternative 2), because it eliminates potential long-term impacts to the public and the environment, complies with all applicable ARARs and allows beneficial future land use. Alternative 3 includes transportation risks associated with shipment of material off-site.

6.1.2 Implementability

Alternatives 1 and 2 can be implemented because they employ established practices that are currently required for managing the Site in its current state. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis. Long-term enforcement of institutional controls under Alternative 2 would require vigilance from local regulatory bodies.

Alternative 3 is implementable because field resources are readily available and project personnel are trained to standard RA procedures.

6.1.3 Cost

The total present-worth cost for Alternative 3 is almost $2,500,000 higher than the total costs for Alternatives 1 and 2, but potential long-term impacts are eliminated under this alternative. There is also significant uncertainty associated with unforeseen events that could occur during the 100-year period evaluated under Alternatives 1 and 2, which could cause the costs of these alternatives to increase significantly.

6.2 Eastern Dog Pens Alternative Comparison

The EDPs Alternatives are compared below.

6.2.1 Effectiveness

Implementation of institutional controls (Alternative 2) would be effective because they would adequately protect the public and the environment from potential exposure until the underlying landfill is remediated. Exposure is highly unlikely during this five-year period if the Site remains in its current state. The No Action alternative (Alternative 1) is less effective, since no action is taken to control site access or prevent the contaminants from being disturbed.

Both of the removal and disposal alternatives (Alternatives 3 and 4) are effective, as they reduce the potential for human health and environmental impacts through elimination of contaminant sources, comply with all ARARs, and facilitate remediation of the underlying landfill. However, the long-term effectiveness is difficult to evaluate, since future land use and the enactment of land-use restrictions will primarily depend on the landfill remediation. Additionally, the disposal alternatives include risks associated with transportation of material off-site.

6.2.2 Implementability

Alternatives 1 and 2 can be implemented easily, because their primary elements are established practices at the Site. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis. Long-term enforcement of institutional controls under Alternative 2 would require vigilance from local regulatory bodies.

Implementation of Alternatives 3 and 4 involve the logistical issues associated with the underlying landfill. Delineation of the EDPs waste and the landfill waste is not clear and there is significant potential to disturb landfill waste during removal of the EDPs waste.

6.2.3 Cost

The total estimated present-worth costs for Alternatives 1 and 2 are significantly lower than the costs for Alternatives 3 and 4, which are primarily affected by the estimated waste volumes. The costs for all four alternatives were estimated over a five-year period assuming that the landfill underlying the EDPs would be remediated during that time.

7. RECOMMENDED ALTERNATIVES

The recommended alternatives for the WDPs and EDPs were selected by determining the best balance of trade-offs between effectiveness, implementability and cost for each alternative. The rationale for selecting the recommended alternatives is discussed below.

7.1 Recommended Alternative for the Western Dog Pens

Alternative 3 (removal and disposal of gravel, concrete curbing and asphalt) is the recommended alternative for the WDPs. With the physical removal of Dog Pens structures, almost three acres of land would be available for future beneficial use, and the potential for public and environmental exposure to residual levels of radionuclides would be eliminated. This alternative complies with all ARARs.

This alternative is implementable; field resources are readily available and project personnel are trained for RA procedures. Alternative 3 is technically feasible.

Although Alternative 3 was the most expensive, it has a defined endpoint and no recurring annual costs. The uncertainty associated with potential human and environmental exposure from leaving the contaminants in place is eliminated when the waste is removed and disposed.

Land use restrictions would be required under Alternatives 1 and 2. The costs associated with these alternatives could increase dramatically if an unanticipated release were to occur during the 100-year performance period.

7.2 Recommended Alternative for the Eastern Dog Pens

Alternative 2 (implementation of institutional controls) is the recommended alternative for the EDPs. Under this alternative, administrative and physical controls would restrict land use pending the remediation of the underlying landfill, which is expected to occur within the next five years. As long as the landfill remains in its current state, institutional controls would be required regardless of which alternative was chosen. Long-term enforcement of institutional controls would require vigilance from local regulatory bodies.

Semi-annual inspections and periodic site maintenance are implementable tasks, as they are routine practices already used for managing the Site. However, any resulting loss of land use would be the subject of future negotiations between DOE and UC Davis. The uncertainty associated with the potential exposure resulting from contaminants left in place is low, given that the performance period is limited to five years. As a result, annual costs associated with these activities are expected to remain minimal.

Alternative 1 may not comply with ARARs. Alternatives 3 and 4 could potentially disturb landfill waste and are more expensive to implement than Alternatives 1 and 2.

8. ASSESSMENT OF ENVIRONMENTAL IMPACTS

8.1 Integration of the NEPA Process with the EE/CA

This section discusses existing environmental conditions and potential impacts that may result from implementing the proposed action or any of the alternatives. This section also reviews environmental impacts in a manner that is consistent with NEPA (*Public Law 91-190*), the Council on Environmental Quality 40 CFR 1500-1508 (*Regulations for Implementing the Procedural Provisions of the NEPA*) and DOE environmental compliance regulations 10 CFR 1021 (*National Environmental Policy Act: Implementing Procedures and Guidelines Revocation; Final Rule and Notice*).

Evaluating environmental considerations of the proposed actions and the alternatives in this EE/CA allows these considerations to be integrated with the CERCLA process, thereby eliminating the need for a separate NEPA analysis, and is consistent with DOE policy and guidance.

8.2 Purpose and Need for Action

The purpose of the proposed actions is to reduce the potential exposure to contaminants potentially present in the Dog Pens to acceptable exposure levels that protect human health and the environment. The actions would meet the RA objectives discussed in Section 4. The proposed actions fulfill a requirement of the Federal Facilities Agreement Under CERCLA Section 120, entered into by DOE and regulatory agencies, to take appropriate response action as necessary to protect human health, welfare or the environment. (FFA, Docket No. 99-17, Section 1.1a)

8.3 Proposed Action and Alternatives

The proposed action and the alternatives for the WDPs are:

- Alternative 1: No Action;
- Alternative 2: Implement institutional controls;
- Alternative 3: Remove concrete, gravel and asphalt and dispose all waste off-site (Proposed Action).

The proposed action and the alternatives for the EDPs are as follows:

- Alternative 1: No Action;
- Alternative 2: Implement institutional controls (Proposed Action);
- Alternative 3: Remove concrete curbs and ship waste off-site; and,
- Alternative 4: Remove concrete, gravel and asphalt and dispose waste off-site.

Table 8-1 summarizes the specific activities for each alternative. Under Alternative 3 for the WDPs and Alternatives 3 and 4 for the EDPs, two shipping options are considered for low-level waste: truck and rail. Transportation impacts are evaluated under Section 8.8.6.

8.4 Alternatives Not Carried Forward for Analysis

One of the alternatives considered and rejected through the screening process was installation of a cover over the WDPs area. It is also inconsistent with the DOE goal of unencumbered transfer of the property to UC Davis as it would limit UC Davis' use of the area and would require DOE access to the area to monitor, maintain and periodically replace the cover.

8.5 Affected Environment

The existing Site environmental setting (discussed in Section 2 and illustrated in Figure 8-1) includes:

- Water resources;
- Ambient air quality;
- Ambient noise quality;
- Aesthetics and scenic values;
- Biological resources (plants and wildlife);
- Flood plains;
- Socioeconomic conditions;
- Historical and cultural resources;
- Land use; and,
- Human health issues.

8.6 Environmental Considerations

The following environmental considerations are discussed in this EA:

- Water resources (ground water, surface recreational waters and stormwater);
- Ambient air quality;
- Ambient noise quality;
- Aesthetics and scenic values;
- Biological resources (plants and wildlife);

- Flood plains;
- Socioeconomic conditions;
- Historical and cultural resources;
- Land use;
- Occupational and public health issues;
- Transportation; and,
- Traffic.

8.7 Environmental Considerations Not Affected by Any of the Alternatives

There are several existing environmental conditions that will not be affected by the proposed actions or any of the alternatives. These include:

- Ground water;
- Surface recreational waters;
- Flood plains;
- Wetlands;
- Aesthetics and scenic values;
- Socioeconomic conditions;
- Historical and cultural resources; and,
- Land use.

Each of these is discussed below.

8.7.1 Ground Water

No impact to ground water is expected as a result of any of alternatives. As discussed in Section 3, the soil contaminant concentrations are below the calculated maximum allowable soil concentrations and pose no threat to this resource.

8.7.2 Surface Recreational Waters

No existing surface recreational waters will be affected by any of the alternatives. No surface or recreational waters are found on the Site. The South Fork of Putah Creek provides recreational opportunities, such as fishing, swimming, boating and other related water activities. This area is about 125 ft south of the Site and is separated from the Site by a levee and a two-lane paved roadway. The RA activities would be separated from recreational areas by sufficient distance to prevent impact to the recreational uses of the creek.

8.7.3 Flood Plains

As shown on federal flood maps, the 100-year flood plain is confined within the Putah Creek levees at the southern boundary of the Site. The Site lies in FEMA Zone C, defined as an area of moderate or minimal hazard from the principal source of flooding in the area. Hazards associated with flood loss are not expected to result from any of the alternatives. None of the alternatives will create any long- or short-term adverse effects associated with occupancy of the floodplain.

8.7.4 Wetlands

A wetland, as defined in 10 CFR 1022.4 (v), is an area that is inundated by surface or ground water with a frequency sufficient to support, and under normal circumstances does or would support, a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. The Site contains no areas that meet this or other wetland definitions. No impacts are expected to any wetlands located off-site (e.g., South Fork of Putah Creek).

8.7.5 Aesthetics and Scenic Values

The proposed actions and alternatives will not affect the aesthetics and scenic values of the area. The present Site appearance does not have high scenic value.

Under Alternative 3 for the WDPs and Alternatives 3 and 4 for the EDPs, the appearance of the Site may change during RA activities; these visual changes are within small localized areas that are normally out of view from the public and public thoroughfares, and is expected to be unnoticed except for individuals working or visiting the Site. Under the removal alternatives, the localized affected areas will be backfilled and graded as appropriate. There will be no long-term impacts to aesthetics and scenic values.

8.7.6 Socioeconomic Conditions

None of the alternatives will affect the socioeconomic conditions of the area. The cost of the project, number of jobs created, money spent in the area, sensitive populations (i.e., minorities, low-income) and land values will have minimal impact on the local area. The RA alternatives would result in the creation of no more than 12 full-time jobs lasting no more than 12 months, which is less than 0.03% of the economy of the City of Davis.

8.7.7 Historical and Cultural Resources

The State Historic Preservation Officer has indicated that there are no known historical and/or cultural resources identified within or adjacent to the Site (UC Davis, 1996b). No historical and cultural resources have been identified on the Site, and because of previous disturbances to the Site, no historical and cultural resources are expected to be uncovered. No impact on historical and cultural resources is expected under any of the alternatives.

8.7.8 Land Use

Land use and values of the Site and adjacent areas will not be adversely affected by any of the alternatives. The Site will remain under the control of UC Davis and will continue to be used for UC Davis educational/research operations, consistent with the UC Davis Long-Range Plan (UC Davis, 1997). The RA alternatives (Alternative 3 for the WDPs) will provide a benefit to UC Davis by allowing the Dog Pens land to be used with no or significantly reduced restrictions.

8.8 Environmental Impacts

This section describes the potential environmental impact of each alternative. Actions associated with each alternative are provided in Table 8-1. Potential impacts of each alternative are summarized in Table 8-2. Potential impacts will be short-term, construction-related impacts affecting:

- Water resources (from stormwater runoff);
- Biological resources;
- Air quality;
- Noise;
- Occupational and public health; and,
- Impacts from transportation of wastes.

Cumulative environmental impacts are discussed in Section 8.8.8.

8.8.1 Water Resources

No impact would result from implementation of Alternatives 1 and 2 because no disturbance of the area causing additional sedimentation to enter stormwater runoff would occur. Long-term impacts may be higher for these alternatives than the RA alternatives, since contamination would remain in place and may enter stormwater runoff during the rainy season. However, as described in Section 2.1.5.2, stormwater generally percolates in WDPs and EDPs with little or no runoff.

Although disturbance of the area would occur under Alternative 3 for the WDPs and Alternatives 3 and 4 for the EDPs, no significant impact to existing water resources is expected. The

RAs proposed under these alternatives would be conducted during the dry season and runoff from the Site is unlikely. However, if rainfall occurs during any earth moving/construction activities, stormwater from the disturbed areas can be affected by the potential presence of contaminants and sediment in the runoff. This impact would be the same for Alternative 4 for the EDPs and Alternative 3 for the WDPs. This impact under Alternative 3 for the EDPs would be lower than other alternatives, because less material will be disturbed.

Under any of the alternatives, potential impact from contaminants in the stormwater runoff will be mitigated by the implementation of Best Management Practices (e.g. berms, drainage control) in accordance with the Clean Water Act. The Best Management Practices are described in the *Final Revised Field Sampling Plan* (Dames & Moore, 1998).

8.8.2 Biological Resources

A list of endangered and threatened species under the Endangered Species Act that may occur in the Merritt and Davis quadrangles, where the Site is located, is provided in Appendix C. A summary of habitats and species actually identified at the Site and nearby during a 1997 Biological Scoping Assessment is provided in Appendix B.

A follow-up Biological Assessment (report in progress) was conducted in March 2000 by John Wolf, Weiss Associates Senior Environmental Scientist, to identify habitats and/or species which may be affected by the proposed action and the alternatives. A potential habitat for the Beetle was identified in both the WDPs and EDPs. The habitat consists of seven elderberry bushes (Figure 8-2). The No Action alternatives and Alternative 2 for the EDPs and WDPs will preserve the status quo in respect to the Beetle habitat and hence will have no effect on the species. All other alternatives will create some disturbance around these bushes, because the concrete curbing to be removed as part of the RA alternatives is near these bushes. However, it is anticipated that the elderberry bushes will be preserved despite these disturbances. Of these alternatives, Alternative 3 for the EDPs presents the lowest impact on the Beetle habitat. Under this alternative, only concrete curbing would be removed, whereas under Alternative 3 for the WDPs and Alternative 4 for the EDPs, gravel and asphalt would be removed in addition to the curbs, creating more disturbance to and around the elderberry bushes.

The March 2000 Biological Assessment will be provided to the United States Fish and Wildlife Service (USFWS) well in advance of commencement of any removal action activities. If a finding of jeopardy to species or adverse habitat modification is made by DOE and/or the USFWS, mitigation measures will be agreed upon with the USFWS prior to beginning of the RA.

In addition to the Beetle, there are wild raptors that periodically use the Site to capture prey; however, the Site is a small area within the raptor's hunting range and should not affect their welfare. Common species of wildlife on the Site will likely be displaced due to excavation/construction activities. However, the surrounding areas will provide suitable habitat for wildlife that is displaced. Once the RAs are completed, the disturbed areas could again be used by wildlife. None of these

common species require protection under existing laws. Any plants that will be removed are introduced species and/or weed-type growth.

8.8.3 Air Quality Impact

No air quality impacts will occur as a result of the No Action alternatives and Alternative 2 for the WDPs and EDPs. These alternatives do not include activities which would create dust.

Alternative 3 for the WDPs and Alternatives 3 and 4 for the EDPs involve earth moving/altering activities and have the potential to create dust. The Site is within a severe non-attainment area for ozone and in a non-attainment area for PM_{10}. Standard dust suppression measures would be taken during construction activities primarily by wetting down the disturbed areas. Any stockpiled loose dirt or materials subject to blowing wind would be covered or placed in containers. Ground cover would be provided at the completion of the RAs as permanent measures to control dust. Air monitoring would be performed during RAs to ensure that no significant adverse impact to air quality is occurring. No significant or adverse long-term impact to the ambient air quality is foreseen.

8.8.4 Noise Impact

The No Action alternatives and Alternative 2 for the WDPs and EDPs will not create any noise impacts.

All other alternatives involve earthwork and construction activities, which would create short-term construction noise. Sensitive receptors may include the raptors in the UC Davis Raptor Center located in small buildings east of the Site. Some of the raptors may be sensitive to noise and experience stress associated with it. The Raptor Center administrators will be notified about any construction activities that may affect the raptors and mitigation measures will be taken, as appropriate. Other species occupying the Site may also experience noise-related stress and temporarily leave the Site. However, considering the small area (three acres) and the limited duration (summer months only) of the RA activities, any impacts associated with noise exposure will be short-term and are not anticipated to cause any significant adverse impact on species occupying the Site.

The noise associated with the RA alternatives may also create a short-term nuisance for the students and faculty who work at the UC Davis ITEH facilities. The noise is not expected to exceed regulatory thresholds, except in the immediate area of the machinery and hence will not create any health impacts for persons other than the operators or workers in the immediate area. Dosimetry equipment will be used to monitor the noise levels and ensure that regulatory thresholds are not exceeded for personnel outside of the construction zone(s). The noise exposure to the LEHR workers will be mitigated by the use of personal protective equipment.

8.8.5 Occupational and Public Health Considerations

The No Action alternatives do not provide for replacement of fencing or other controls over time. Under this alternative the present contamination will remain at the Site and may present public health impacts, especially if the site controls degrade and access to the public (including UC Davis staff and students) is not well controlled. No occupational health impacts will result if this alternative is chosen, because no work at the Site will be performed.

Alternative 2 for the EDPs and WDPs would also leave contamination in place, but site controls would be maintained to prevent public access to contaminated areas. These institutional controls are expected to preclude any public health impacts. No significant occupational exposure is expected to result from these alternatives. Workers would potentially come into contact with low-level radioactive materials during maintenance activities, but the exposure would be minimal and mitigated by the use of personal protective equipment and adherence to site- and activity-specific HSPs.

All other alternatives will require worker contact with low-level radioactive materials. Worker protection will be provided in accordance with site- and activity-specific health and safety plans, and compliance with OSHA and DOE regulations concerning the handling of low-level radioactive materials. Only personnel trained in hazardous waste operations and emergency response will be allowed to conduct RA field activities. Protective clothing would be used when working with radioactive materials. These precautions will ensure that worker health is protected.

Activities associated with Alternative 3 in the WDPs would be in close proximity to a UC Davis building occupied by university staff. Engineering controls would be implemented and air monitoring would be conducted as necessary to ensure that there is no impact to the building occupants from airborne contaminants generated by the RAs.

Because they are geographically confined to the Site, RA activities are not expected to produce off-site public health consequences (except for possible transportation impacts, discussed below). Access to the areas in which RA activities occur would be controlled, eliminating any potential health impact to members of the public who enter the Site.

8.8.6 Transportation of Waste

If the No Action alternatives or Alternative 2 for the EDPs and WDPs are selected, no waste will be generated and no waste shipments will occur, thereby resulting in no impact from waste transportation. If any other alternatives are chosen, no significant adverse impacts are expected to result from transportation of waste to disposal facilities, as discussed below.

Shipments of both low-level radioactive waste and non-hazardous waste are anticipated as part of Alternative 3 for the WDPs and Alternatives 3 and 4 for the EDPs. Waste material will be transported off-site by either truck or rail. Waste will be packaged in proper containers and in

compliance with appropriate Department of Transportation regulations and DOE waste packaging requirements. Potential impacts associated with these shipments are discussed below.

8.8.6.1 Radiological Impacts

Estimated waste volumes and numbers of truck and rail shipments of low-level radioactive waste for each alternative are shown in Tables 8-3 and 8-4, respectively.

Radionuclides of interest for assessing routine transportation impacts are those that present direct radiation exposure hazards to drivers of the truck transporting the waste or members of the public; these include Ra-226 and Sr-90. The highest observed concentrations of these radionuclides in the Dog Pens (Table 8-5) were used to estimate radiation exposure during transportation activities. The total activity of each radionuclide of interest per truckload and rail car is shown in Table 8-5.

8.8.6.1.1 Radiological Impacts Associated with Truck Shipments

The total distance per truck shipment is approximately 650 miles from the Site to Envirocare of Utah, the final disposal site, via I-80. Assuming an average speed of 45 miles per hour, the duration of exposure to a driver would be 14.44 hours for each trip. These assumptions were input into a standard radiation exposure model (MicroShield, Version 5), and the worst case exposure to each driver was calculated as 2.83×10^{-4} millirem per trip. Assuming that one driver delivers all of the loads under each alternative (most conservative, although unlikely, scenario), the highest exposure to the driver is 1.84×10^{-2} millirem, in Alternative 3 for the WDPs. Due to the likely use of multiple drivers and use of maximum radiological activities in the risk calculation, the actual exposure to a driver is likely to be at least one order of magnitude below this dose. Even in the worst case the estimated dose is well below the 100 millirem (0.1 rem) per year dose limits for individual members of the public established by the Nuclear Regulatory Commission (NRC) (10 CFR 20.1301).

The population dose under any of the RA alternatives would be minimal. The highest exposure for a member of the public is at truck stops when there is the longest potential exposure time. The population dose calculation, based on a population density of 3,861 people per square kilometer, a very conservative estimate of the population density along the route, estimates the exposure as 4.64×10^{-6} person-rem per trip (RISKIND, Version 1.11). With 67 trips, the highest number in any of the alternatives, the collective population dose is 3.1×10^{-4} person-rem, which using a general population dose-to-risk conversion factor of 5×10^{-4} cancer fatalities per person-rem (NRC, 1991) corresponds to 1.55×10^{-7} latent cancer fatalities.

Radiation exposure risks associated with accidents would be insignificant. Over the total life of the RAs, assuming 110 total low-level waste shipments, the accident frequency is projected to be less than one accident for the entire project. This assumes that the route traveled is 10% on urban interstates and 90% on rural interstates. According to a Federal Highway Administration study (Miaou, 1991), associated accident rates are 1.86 for urban interstates and 0.88 for rural interstates per million truck miles. These accidents were moderately severe, resulting in a vehicle being towed from the accident site. Accordingly, the total number of projected accidents, over 1,300 miles per trip and 110 trips, would be 0.14. Statistically, it is highly unlikely that an accident resulting in any release or significant exposure would occur.

A conservative estimate of public radiation exposure from an accident is calculated as 1.46 x 10^{-6} person-rem (RISKIND, Version 1.11) assuming a population density of 3,861 people per square mile. This collective dose to the public is estimated to result in 7.3 x 10^{-10} latent cancer fatalities.

8.8.6.1.2 Radiological Impacts Associated with Rail Shipments

The radiological impacts associated with rail shipments would be lower then those associated with truck shipments. The distance covered by the train route is approximately the same as that for the highway route: 650 miles one way. The train operator is further from the low-level waste material than in the case of the truck driver and additional shielding is provided by the locomotive. Both of these factors reduce the train operator's potential radiation exposure below the exposure calculated for the truck shipments, which is orders of magnitude below the NRC limit and will be much lower in case of the rail shipments. The calculated collective population dose at rail stops, when the potential for public exposure is the longest, is 1.24 x 10^{-5} person-rem per trip (RISKIND Version 1.11). This collective dose was calculated using a population density of 3,861 people per square kilometer and corresponds to an average individual radiation dose of 3.2 x 10^{-6} millirem per trip. In the case of Alternative 3, which has the highest number of shipments (4), the total collective dose for all trips is 4.96 x 10^{-5} person-rem. The worst case collective dose (Alternative 3 with the highest number of shipments) is estimated to result in 2.48 x 10^{-8} latent cancer fatalities.

Radiation exposure risks associated with accidents are expected to be very low. According to a Federal Railroad Administration (Railroad Safety Statistics Annual Report 1998, July 1999), Union Pacific Railroad had a total of 16 incidents involving hazardous materials releases per 1,573 rail cars in 1998 (0.01 accidents per car). Hazardous material is defined by the Federal Railroad Administration as "any substance or material, including hazardous substance, which has been determined by the Secretary of Transportation to be capable of posing an unreasonable risk to health, safety or property when transported in commerce, and which has been so designated". Low-level radioactive waste is a hazardous material under this definition. The total number of projected incidents for each alternative is presented in Table 8-6. The likelihood of an incident resulting in any release or significant exposure is very low. The estimated radiation dose to a member of the public associated with a train accident is calculated to be 3.86 x 10^{-6} person-rem (RISKIND, Version 1.11) or the equivalent of an estimated 1.9 x 10^{-9} latent cancer fatalities.

8.8.6.2 Non-Radiological Impacts

8.8.6.2.1 Impacts Associated with Truck Shipments

Non-radiological impacts include motor vehicle-related fatalities and air quality impacts associated with exhaust and road dust. These impacts would be associated with both low-level radioactive waste and non-hazardous waste shipments. Estimated waste volumes and numbers of truck shipments of low-level radioactive waste and non-hazardous waste for each alternative are shown in Table 8-3. The maximum distance is 1,300 miles round trip for low-level waste shipments and 10 miles round trip for non-hazardous waste shipments. The non-hazardous waste disposal site is assumed to be the Yolo County Central Landfill.

The probability of an accident resulting in a fatal injury has been computed using data from the U.S. Department of Transportation National Highway Traffic Safety Administration (U.S. Department of Transportation, National Highway Traffic Safety Administration, Traffic Safety Facts, 1998) and is shown in Table 8-7. The fatality rate for large trucks is 2.82 per 100 million miles traveled. Based on this rate, the highest probability of a fatality is 2.52×10^{-3}, under Alternative 3 for the WDPs.

Similarly, the risk of latent fatalities from exposure to diesel exhaust and entrained road dust for residents along the highway in urban areas has been estimated to be 6.21×10^{-8} fatalities per mile (Rao *et al*, 1982). Assuming as much as 10% travel though urban areas, the highest risk of dying from exposure to exhaust and road dust for people in urban areas would be very low, 5.56×10^{-4}, under Alternative 3 for the WDPs (Table 8-7).

8.8.6.2.2 Impacts Associated with Rail Shipments

Non-radiological impacts associated with rail shipments include fatalities due to train accidents and fatalities associated with highway-rail crossings. Only the low-level waste would potentially be shipped by rail. Estimated waste volumes, numbers of rail cars and number of train shipments of low-level radioactive waste for each alternative are shown in Table 8-4. The maximum distance of each train shipment is 650 miles per trip.

The expected number of accidents resulting in a fatal injury has been computed for each alternative using data from the U.S. Department of Transportation Federal Railroad Administration (U.S. Department of Transportation, Federal Railroad Administration, Railroad Safety Statistics, Annual Report 1998, July 1999). These data are included in Table 8-8. The railroad statistics used are those reported for Union Pacific Railroad, which is the standard carrier for the Davis area. The number of fatal train accidents on Union Pacific's rail lines was 1 in 142,913,853 miles of freight shipped in 1998. The number of Union Pacific Railroad highway-rail crossing fatalities was 89 for 142,913,853 miles of freight shipped in 1998 (6.2×10^{-7}). The number of projected rail-crossing fatalities resulting from any of the alternatives is provided in Table 8-8. The probability of a fatal accident for any of the action alternatives is very low, 8.19×10^{-4} (the highest projected total fatalities is expected to occur under Alternative 4 for the EDPs).

8.8.7 Traffic

Under Alternative 3 for the WDPs and Alternatives 3 and 4 for the EDPs, truck traffic will increase near the Site for a short period of time due to transportation of waste from the Site to a disposal facility, and an increase in personnel at the Site due to the construction activities. The traffic increases will be the same whether trucks or rail are used for the low-level waste shipments because trucks would be utilized to move the waste from the Site to the rail depot.

The traffic increase due to transportation of waste is greatest under Alternative 3 for the WDPs. Under this alternative, 346 additional trucks will enter and leave the Site. The number of additional trucks for the EDPs would be 38 for Alternative 3 and 126 for Alternative 4 (Table 8-3).

The increased traffic during transportation of waste from the Site would affect the local area for a short period of time. The Site is located less than one mile from a major highway (I-80) and hence street traffic would be limited to a small portion of Old Davis Road. Strategic scheduling of waste transportation activities would be used to minimize potential traffic effects. The impact would also be mitigated by the use of traffic controls such as barriers, flags and trained traffic control personnel.

The impact of increased traffic due to additional personnel at the Site would be minimal. As discussed in Section 8.6, the personnel increase resulting from any of the RA alternatives would be negligible (less than .03% of the City of Davis work force). Separate parking facilities would be provided for the Site personnel to mitigate any impact to UC Davis staff.

8.8.8 Cumulative Impacts

Cumulative impacts for the Dog Pens remedial alternatives are categorized into potential short-term cumulative impacts related to construction activities involving RAs, or potential long-term cumulative impacts associated with the release of COPCs into the environment, as discussed below.

- Short-Term Cumulative Impacts—UC Davis will also be conducting remedial action(s) associated with their landfill areas on contiguous portions of the Site. These activities would increase construction-related impacts at the Site and adjacent areas. There are no other known projects at the Site or in the vicinity which would require consideration in evaluating cumulative impacts of the proposed actions and the alternatives.
- Long-Term Cumulative Impacts—No long-term cumulative impacts are expected as a consequence of any of the RA alternatives. Implementation of these alternatives would decrease any potential long-term impacts to human health and environment by removing and disposing contaminated material from the Site. Impacts of the Alternatives 1 and 2 for both WDPs and EDPs, may include contamination of runoff from the Site. The No Action alternatives may present a potential public health hazard because contact with contamination may result if the public has access to the Site.

8.9 Mitigation Measures

Mitigation measures will be implemented as necessary, prior to and during RAs to ensure no environmental impacts occur. Mitigation measures to be implemented are summarized in Table 8 - 10.

8.10 List of Agencies and Persons Consulted

The local agencies and persons consulted for this EA are identified on Table 8-10.

8.11 List of Preparers

Agata A. Sulczynski, JD, REA, Project Scientist, Weiss Associates

John A. Wolf, REA, Senior Environmental Scientist, Weiss Associates

8.12 Summary of Environmental Impacts

Evaluation of the likely environmental impacts associated with all of the alternatives discussed in this EE/CA indicates that there would be either no impact or minimal impact to the environment should any of RA alternatives be selected. There are five values that are not expected to be impacted at all. These are: wetlands, aesthetics and scenic values, socioeconomic conditions, historical and cultural resources and land use. Short-term, minimal impacts would occur in the following areas: water resources, biological resources, air quality, noise, occupational and public health considerations and transportation of low-level radioactive waste. These impacts are expected to be short-term, minimal and fully mitigated by compliance with existing regulations. Most impacts (such as dust and noise) would be limited to the Site and immediate surroundings, and are expected to have no long-lasting consequences. No long-term impacts are expected as a consequence of any of the action alternatives.

Table 8-1. Description of Work Actions by Alternative

Types of Work Actions	Western Dog Pens			Eastern Dog Pens			
	Alternative 1 (No Action)	Alternative 2	Alternative 3 (Proposed Action)	Alternative 1 (No Action)	Alternative 2 (Proposed Action)	Alternative 3	Alternative 4
	Site Inspections	Institutional Controls	Removal of gravel, concrete and asphalt and Off-site Disposal	Site Inspections	Institutional Controls	Removal of Concrete Curbs, Off-site Disposal and Institutional Controls	Removal of Gravel, Concrete Curbs and Asphalt, Off-site Disposal
1. Mobilization			✓			✓	✓
2. Site Preparation			✓			✓	✓
3. Gravel Removal			✓				✓
4. Concrete Removal			✓			✓	✓
5. Asphalt Removal			✓				✓
6. Sampling Activities			✓			✓	✓
7. Segregating Waste			✓			✓	✓
8. a) Packaging/Transport to Class III Landfill			✓			✓	✓
b) Packaging/Transport to Low-Level Waste Disposal Facility			✓			✓	✓
9. Importing and Placing Clean Soil Fill			✓				✓
10. Final Grading			✓			✓	✓
11. Landscaping			✓				
12. Demobilization			✓			✓	✓
13. Site Inspections	✓	✓		✓	✓	✓	
14. Area Monitoring		✓			✓	✓	
15. Site Controls (e.g., fence)		✓			✓	✓	
16. Site Surveillance	✓	✓		✓	✓	✓	

Notes:
For a description of the Alternatives see Section 5.

Table 8-2. Potential Environmental Impacts By Alternative

	Western Dog Pens			Eastern Dog Pens			
	Alternative 1 (No Action)	Alternative 2	Alternative 3	Alternative 1 (No Action)	Alternative 2	Alternative 3	Alternative 4
	Site Inspections	Institutional Controls	Removal of Gravel, Concrete Curbs and Asphalt, + Off-site Disposal	Site Inspections	Institutional Controls	Removal of Concrete Curbs, Off-site Disposal and Institutional Controls	Removal of Gravel, Concrete Curbs and Asphalt + Off-site Disposal
1. Water Resources	O	O		O	O		
2. Air Quality Impact	O	O	O	O	O		
3. Noise Impact	O	O		O	O		
4. Aesthetics and Scenic Values	O	O	O	O	O	O	O
5. Biological Resources	O	O		O	O		
6. Flood Plains	O	O	O	O	O	O	O
7. Wetlands	O	O	O	O	O	O	O
8. Socioeconomic Conditions	O	O	O	O	O	O	O
9. Historical and Cultural Resources	O	O	O	O	O	O	O
10. Land Use	O	O	O	O	O	O	O
11. Occupational and Public Health	●	O		●	O		
12. Transportation	O	O		O	O		
13. Traffic	O	O		O	O		
14. Cumulative Impacts	O	O		O	O		

Notes and abbreviations:

O = No foreseeable impact.
= Short-term negligible (construction-type) impacts; mitigation measures will be implemented to minimize adverse impacts.
● = Potential significant and/or adverse impacts – may not meet Removal Action Objectives or National Contingency Plan criteria.

Table 8-3. Estimated Waste Volumes and Truck Shipments by Alternative

	Western Dog Pens			Eastern Dog Pens			
	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Low-Level Waste							
Estimated Volume of Material (cubic yards) [a]	0	0	667	0	0	180	241
Total Number of Trucks [b]	0	0	67	0	0	18	25
Miles Traveled [c]	0	0	87,100	0	0	23,400	32,500
Non-Hazardous Waste							
Estimated Volume of Material (cubic yards) [a]	0	0	2,786	0	0	198	1,006
Total Number of Trucks [b]	0	0	279	0	0	20	101
Miles Traveled [d]	0	0	2,790	0	0	200	1,010
Low-Level Waste and Non-Hazardous Waste							
Total Number of Trucks [b]	0	0	346	0	0	38	126
Miles Traveled	0	0	89,890	0	0	23,600	33,510

Notes:
[a] Based on estimated volumes identified in Appendix A.
[b] Based on 10 cubic yards of waste per truck (rounded to the next whole number).
[c] Based on 1,300 miles per round trip.
[d] Based on 10 miles per round trip.

Table 8-4. Estimated Low-Level Waste Volumes Rail Shipments by Alternative

	Western Dog Pens			Eastern Dog Pens			
	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Estimated Volume of Material (cubic yards) [a]	0	0	667	0	0	180	241
Estimated Weight of Material (tons)	0	0	3,321	0	0	182	1,237
Total Number of Rail Cars [b]	0	0	34	0	0	4	13
Total Number of Shipments [c]	0	0	4	0	0	1	2
Miles Traveled [d]	0	0	2,600	0	0	650	1,300

Notes:
[a] Based on estimated volumes identified in Appendix A.
[b] Based on maximum 50 cubic yards or 100 tons of waste per truck (rounded to the next whole number).
[c] Based on 10 rail cars per shipment.
[d] Based on 650 miles per trip.

Table 8-5. Maximum Observed Radium-226 and Strontium-90 Activity in Waste from Eastern and Western Dog Pens

Radionuclide	Maximum Observed Activity (pCi/g)[a]		Maximum Activity per Shipment (μCi)[b]		
	WDP	EDP	Alt. 3 WDP	Alt. 3 EDP	Alt. 4 EDP
Truck Shipments					
Ra-226	1.94	1.68	87.4	15.4	78.1
Sr-90	7.44	7.44	3.35×10^2	68.1	3.46×10^2
Rail Shipments[c]					
Ra-226	1.94	1.68	1.76×10^3	7.69×10^2	1.52×10^3
Sr-90	7.44	7.44	6.73×10^3	3.4×10^3	6.73×10^3
Waste Material Density (tons per cubic yard)			4.98	1.01	5.13

Notes:

[a] See Section 3 for additional information.
[b] Assumes 10 cubic yards of material per shipment by truck and 50 cubic yards or 100 tons per rail car.
[c] Assumes 10 rail cars per shipment.

Abbreviations:

μCi	microCuries
Alt.	Alternative
pCi/g	picoCuries per gram
Ra-226	Radium-226
Sr-90	Strontium-90

Table 8-6. Expected Number of Incidents Resulting in a Release of Hazardous Materials (Rail Shipments)

	Western Dog Pens			Eastern Dog Pens			
	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Number of Rail Cars	0	0	34	0	0	4	13
Expected Number of Accidents [a]	0	0	0.35	0	0	0.04	0.13

Notes:

[a] Based on Union Pacific's 1998 rate of 16 accidents involving release of hazardous materials per 1,573 rail cars carrying hazardous materials (U.S. Department of Transportation, Federal Railroad Administration, Railroad Safety Statistics Annual Report 1998, July 1999).

Table 8-7. Statistical Highway Fatality Rate per Alternative (Truck Shipments)

	Western Dog Pens			Eastern Dog Pens			
	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Miles Traveled	0	0	89,500	0	0	23,600	33,510
Probability of Fatality [a]	0	0	2.52×10^{-3}	0	0	6.66×10^{-4}	9.45×10^{-4}
Probability of Fatality due to Road Dust and Diesel Exhaust [b]	0	0	5.56×10^{-4}	0	0	1.47×10^{-4}	2.08×10^{-4}

Notes:
[a] Based on 2.82 fatalities per 100 million miles traveled for large trucks (U.S. Department of Transportation, 1998 Traffic Safety Facts 1998).
[b] Based on 6.21×10^{-8} fatalities per mile (Rao et al, 1982) and 10% travel through urban areas.

Table 8-8. Expected Railroad Fatality Rate per Alternative

	Western Dog Pens			Eastern Dog Pens			
	Alternative 1	Alternative 2	Alternative 3	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Total Number of Rail Cars	0	0	34	0	0	4	13
Miles Traveled [a]	0	0	22,100	0	0	650	1,300
Expected Number of Fatal Accident [b]	0	0	1.55×10^{-4}	0	0	4.55×10^{-6}	9.10×10^{-6}
Expected Number of Fatalities at Highway-Rail Crossings [c]	0	0	1.38×10^{-2}	0	0	4.05×10^{-4}	8.10×10^{-4}
Total Number of Expected Fatalities	0	0	1.39×10^{-2}	0	0	4.09×10^{-4}	8.19×10^{-4}

Notes:

[a] Assumes 10 rail cars per shipment and 650 miles per trip.

[b] Based on 1 train fatality per 142,913,853 (7×10^9) freight miles traveled by Union Pacific Railroad in 1998. (U.S. Department of Transportation, Federal Railroad Administration, Railroad Safety Statistics, Annual Report 1998, July 1999).

[c] Based on 89 highway-rail crossing fatalities per 142,913,853 (6.23×10^7) freight miles traveled by Union Pacific Railroad in 1998 (U.S. Department of Transportation, Federal Railroad Administration, Railroad Safety Statistics, Annual Report 1998, July 1999)

Table 8-9. Mitigation Measures for Potential Environmental Impacts

Impact Areas	Mitigation Measures
Water Resources	• Stormwater runoff and sediment will be impounded on-site to prevent surface runoff; and, • Erosion control measures will be implemented to reduce sediment transport to creek.
Biological Resources	• A focused biological resource survey will be conducted prior to the RAs; • Mitigation, if any, for endangered or threatened species and/or habitat will be implemented as identified by USFWS; and, • RAs will be halted and appropriate measures will be implemented if a biological resource will be impacted.
Historical and Cultural Resources	• RA activities will be halted if any cultural resources are uncovered so that appropriate actions can be implemented.
Air Quality	• Dust suppression during construction activity using water or other approved liquids; • Covering or containment of loose soil piles/areas when there is no work activity; and, • Air monitoring to ensure public protection.
Noise Impact	• Advise Raptor Center of construction noise activities; • Monitor noise exposure for worker and university personnel; • Provide personal protective equipment for workers exposed to noise as necessary; and, • Use equipment that would produce less noise if possible.

Table 8-9. Mitigation Measures for Potential Environmental Impacts (continued)

Impact Areas	Mitigation Measures
Human Health	• Conduct field, transportation, packaging and disposal activities related to wastes according to the site-specific health and safety plan procedures. This includes using the appropriate personal protective equipment required for the activity; • Implement modifications to HVAC systems for buildings in close proximity to RA activities likely to generate airborne contaminants; • Monitor air quality as necessary for buildings in close proximity to RA activities which can generate airborne contaminants; • Use decontamination facilities and procedures as appropriate; and, • Train staff on procedures for emergencies and accidents.
Transportation of Low-level Radioactive Waste	• Adhere to applicable DOT regulations (49 CFR 173) relating to the packaging, handling, labeling, disposal, routing, and transporting of low-level radioactive waste; including driver training and regulations.
Local Traffic	• If traffic from the removal actions would result in increased ingress/egress from the Site, then traffic control on Old Davis Road would be provided.
Cumulative Impacts	• Monitoring of other Site activities will be conducted during RA and work will be halted as required to implement mitigation measures.

Abbreviations:

DOT	Department of Transportation
HVAC	Heating, Ventilation and Air Conditioning
RAs	Removal Actions
USFWS	U.S. Fish and Wildlife Service

Table 8-10. Local Agencies Contacted

Agency/Person/Title	Date	Subject
Planning and Building Department, City of Davis Martha Aja, Planner	March 15, 2000	Land use information
UC Davis Environmental Health & Safety, Brian Oatman, Project Manager	March 20, 2000	Planned projects in the area
City Manager's Office, Doug Grandquis, Economic Development Coordinator	March 15, 2000	Population/commerce information
Yolo/Solano Air Quality Management District, Dave Smith, Compliance Officer	March 15, 2000	Ambient air quality information
United States Fish and Wildlife Service, Harry Mossman, Staff	March 14, 2000	Endangered Species Act compliance
California Office of Historic Preservation, Northwest Information Center, Lee Jordan, Coordinator	June 26, 1998 and April 12, 2000	Historical and Cultural Resources

EXPLANATION

1. Main building (H-213)
2. Cellular Biology Laboratory (H-294)
3. Co-60 Annex (H-290)
4. Co-60 Building (H-229)
5. Specimen storage (H-216)
6. Animal Hospital No. 1 (H-219)
7. Animal Hospital No. 2 (H-218)
8. Geriatrics Building No. 1 (H-292)
9. Geriatrics Building No. 2 (H-293)
10. Small Animal Housing (H-296)
11. Storage space (H-300)
12. Maintenance shop (H-212)
13. Toxic Pollutant Health Research Laboratory (H-299)
14. Reproductive Biology Laboratory (H-215)
15. Occupational and Environmental Medicine Building (H-289)
16. Inter-Regional Project No. 4 (H-217)
17. Western Dog pens
18. Eastern Dog pens
19. Southwest Trench Area
20. DOE Disposal Box (removed)
21. Location of former Imhoff building (H-214), strontium-90 and radium-226 leach fields and the radium-226 waste tanks, Imhoff storage tanks
22. Cobalt-60 irradiation field

DT-1 Septic Tanks

\# Locations of future DOE Remedial Actions

DOE Potential/Known Source Area

UC Davis Potential/Known Source Area

Remediated Area

Noise Sensitive Area-Raptor Center

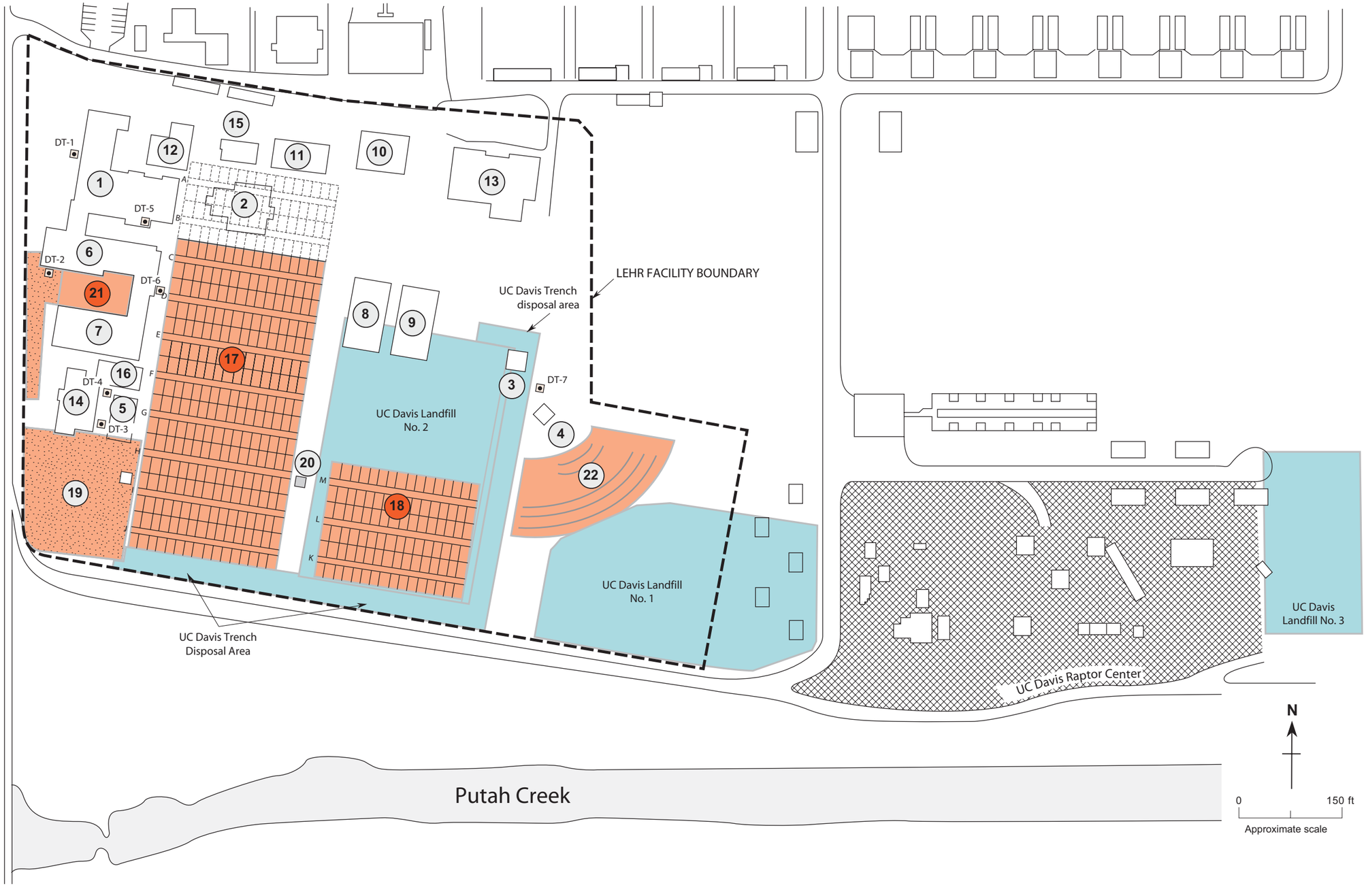

Figure 8-1. Environmental Setting

Weiss Associates

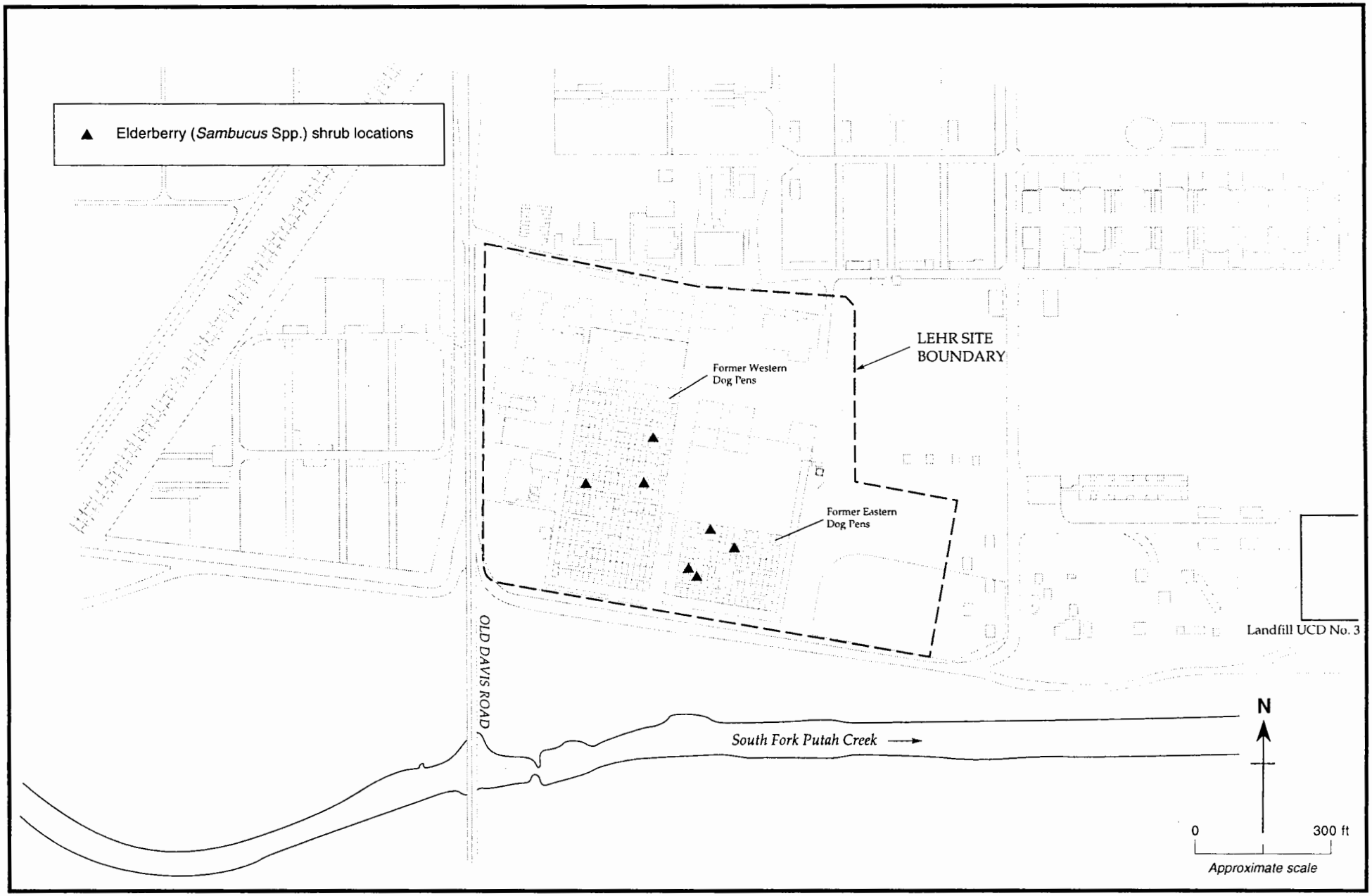

Figure 8-2. Potential Habitat of Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*) in the Former Western and Former Eastern Dog Pens, LEHR Site, UC Davis, California

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APPENDIX A

COST ESTIMATE SUMMARIES FOR REMOVAL ACTION ALTERNATIVES

COST ESTIMATE SUMMARIES FOR REMOVAL ACTION ALTERNATIVES

A.1 General Assumptions

This appendix presents background cost estimates for the removal alternatives described in Section 5. It includes flow charts that describe the process step assumptions to be performed and tables that specify assumptions and costs. The assumed process steps are preliminary and subject to modification in the work plan.

This section provides the preliminary cost estimates for the removal actions (RAs) being evaluated in the Engineering Evaluation/Cost Analysis (EE/CA) for the Western and Eastern Dog Pens (Dog Pens) at the Laboratory for Energy-Related Health Research (LEHR). Cost estimates were developed for all Western Dog Pens (WDPs) and Eastern Dog Pens (EDPs) alternatives. These cost estimates are used in the body of the EE/CA to compare the financial implications between the alternatives evaluated.

These cost estimates are intended to provide an accuracy of +50% to -30%. The accuracy range is for uncertainties involved in developing the costs for the assumed volume of debris and waste. There are also uncertainties in calculating the assumed debris and waste removal volumes. The uncertainties in debris and waste volumes are not reflected in these cost estimates. It is likely that increased volumes will increase the costs linearly.

Three alternatives were developed for the WDPs:

- Alternative 1: No Action;
- Alternative 2: Implement institutional controls; and,
- Alternative 3: Remove and dispose gravel, concrete curbs and asphalt.

Four alternatives were developed for the EDPs:

- Alternative 1: No Action;
- Alternative 2: Implement institutional controls;
- Alternative 3: Remove and dispose concrete curbs; and,
- Alternative 4: Remove and dispose gravel, concrete curbs and asphalt.

These estimates are to be used for cost comparison of the RAs and are not intended to be inclusive or represent the final RA costs. The final cost of the RA will vary based on several key factors including debris and waste volumes, debris and waste characteristics, contractor costs at the

time the work is undertaken, actual schedule of implementation and special rates negotiated with transportation and disposal contractors.

These costs target the primary cost components which have the greatest impact on the RAs. The key cost components are given unit cost values based on current project costs; Weiss Associates- and vendor-supplied cost estimates; and construction cost guides for environmental, excavation and earthwork activities.

The cost estimate models are most sensitive to the changes in estimated debris and waste volumes. Therefore, the most significant primary costs are debris and waste transportation, and disposal costs. These components have high unit costs as compared to the other unit costs and are dependent on debris and waste volumes generated during the RA. Changes in the debris and waste volumes reflect a significant change in the cost estimate.

A.2 Technical Approach Assumptions

- Volume and weight values of materials to be removed are based upon WDPs dimensions. EDPs volume and weight values calculated from averages per pen of WDPs.
- Only one round of excavation followed by confirmation samples is required.
- No sampling or removal of leaching trench gravel occurs in the WDPs, although water pipes in the trench will be removed.

A.3 Cost Assumptions

- Land use restriction cost estimate is assumed to be $100,000; the actual cost may vary. This cost includes land replacement and the application of deed restrictions.
- Sample analysis rates are based on contracted rates from General Engineering Labs in South Carolina.
- Heavy equipment rental rates are based on 1999 contracted rates from Hertz Equipment Rental Corporation in West Sacramento, California.
- Waste shipment and disposal rates are based on vendor quotes and Weiss Associates' experience and professional judgement.
- Production estimates are based on Weiss Associates' experience on similar projects and professional judgement.
- Radiological production estimates are based on IT Corporation's experience at the Site.
- Field labor estimates are based upon a 10-hour workday.

Western Dog Pens Alternative 1
No Action

Task	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Work Plan	1	ls	$ 5,000	$ 5,000
Direct Capital Costs Subtotal:				**$ 5,000**
INDIRECT CAPITAL COSTS				
Project Management - 10% of total			10%	$ 1,000
Indirect Capital Costs Subtotal:				**$ 1,000**
Capital Costs Subtotal:				**$ 6,000**
ANNUAL COSTS				
Semi-Annual Site Inspection	1	ls	$ 10,000	**$ 10,000**
Annual Costs Subtotal:				**$ 10,000**
Present Worth of Annual Costs Subtotal: (At 7% for 100 years)				$ 143,000
TOTAL COSTS:				**$ 149,000**

Abbreviations
ls lump lum
sf square feet

Western Dog Pens Alternative 2
Implement Institutional Controls

Task	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Work Plan	1	ls	$ 5,000	**$ 5,000**
Land Use Restrictions	1	ls	$ 100,000	**$ 100,000**
Install Fence every 20 years (1,314 lineal ft x 5)	6,570	lf	$ 10	**$ 66,000**
Direct Capital Costs Subtotal:				**$ 171,000**
INDIRECT CAPITAL COSTS				
Project Management - 10% of total			10%	$ 18,000
Indirect Capital Costs Subtotal:				**$ 18,000**
Capital Costs Subtotal:				**$ 189,000**
ANNUAL COSTS				
Semi-Annual Site Inspection	1	ls	$ 10,000	**$ 10,000**
Annual Costs Subtotal:				**$ 10,000**
Present Worth of Annual Costs Subtotal: (At 7% for 100 years)				$ 143,000
TOTAL COSTS				
TOTAL COSTS:				**$ 332,000**

Abbreviations

lf linear feet
ls lump sum

Western Dog Pens Alternative 3
Gravel, Concrete Curbs, Fence and Asphalt Removal and Disposal

Task	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Preliminary Planning Tasks				
Work Plan for Background Investigations (Concrete and Gravel)	1	ls	$ 25,000	$ 25,000
Background Investigation Management and Reporting	1	ls	$ 20,000	$ 20,000
Collect Background Samples	40	ea	$ 187	$ 8,000
Background Sample Analysis Costs (Radiological Sample Suite)	40	ea	$ 1,143	$ 46,000
Sampling and Analysis Plan to Pre-Characterize Asphalt and Concrete	1	ls	$ 25,000	$ 25,000
Radiological Surface Survey of Asphalt and Concrete Curbing	559	survey	$ 162	$ 91,000
Survey Equipment Modification Costs	1	ls	$ 15,000	$ 15,000
Collect Composite Samples	53	ea	$ 187	$ 10,000
Composite Analysis Costs (Full Suite Sample Analysis)	53	ea	$ 2,300	$ 122,000
Validate Data and Wilcoxon Rank Sum Test	1	ls	$ 20,000	$ 20,000
Risk Modeling for Exposure	1	ls	$ 20,000	$ 20,000
Submittal to DHS for Sanitary Landfill Disposal Exemption	1	ls	$ 5,000	$ 5,000
Removal Action				
Removal Action Work Plan	1	ls	$ 80,000	$ 80,000
Remove Perimeter Fencing, Install Temp Fence	1,314	lf	$ 10	$ 13,000
Radiological Survey of Fence	1,314	lf	$ 6	$ 8,000
Install Temporary Fence	1,314	lf	$ 2	$ 3,000
Geophysical Surveys	1	ls	$ 15,000	$ 15,000
Modify Cellular Biology HVAC	1	ls	$ 20,000	$ 20,000
Remove Surface Gravel to Roll-off Containers	1,825	cy	$ 34	$ 62,000
Remove Rad-Added Asphalt and Concrete to Roll-off Containers	667	cy	$ 23	$ 16,000
Remove Clean Asphalt and Concrete to Roll-off Containers	2,786	cy	$ 21	$ 59,000
Screen Material to Remove Fines	458	cy	$ 23	$ 11,000
Collect Composite Samples	23	ea	$ 187	$ 5,000
Composite Analysis Costs (Full-Suite Sample Analysis)	23	ea	$ 2,300	$ 52,000
Shipment and Disposal of Material to Envirocare	667	cy	$ 900	$ 601,000
Shipment and Disposal of Material to Landfill	5,332	ton	$ 60	$ 320,000
Final Radiological Survey	72	survey	$ 162	$ 12,000
Collect Confirmation Samples	70	ea	$ 89	$ 7,000
Analyze Confirmation Samples (Ra-226, Sr-90, Pesticides)	70	ea	$ 455	$ 32,000
Validate Confirmation Sample Data	1	ls	$ 10,000	$ 10,000
Import Fill, Compact and Grade	3,450	cy	$ 11	$ 39,000
Import Clean Fill	3,450	cy	$ 15	$ 52,000
Geotextile Fabric to Delineate Excavation Area	102,465	sf	$ 0.09	$ 10,000
Decon Equipment	1	ls	$ 6,133	$ 7,000
Summarize Results in Dog Pens Confirmation Report	1	ls	$ 25,000	$ 25,000
Contingency - 20% of total			20%	$ 374,000
Direct Capital Costs Subtotal:				$ 2,240,000
INDIRECT CAPITAL COSTS				
Engineering and Design - 10% of total			10%	$ 224,000
Permitting - 5% of total			5%	$ 112,000
Project Management - 10% of total			10%	$ 224,000
Indirect Capital Costs Subtotal:				$ 560,000
Capital Costs Subtotal:				$ 2,800,000
ANNUAL COSTS				
Annual Costs Subtotal:				$ -
Present Worth of Annual Costs Subtotal: (At 7% for 100 years)				$ -
TOTAL COSTS				
TOTAL COSTS:				$ 2,800,000

Abbreviations

cy	cubic yard
ea	each
lf	linear feet
ls	lump sum
sf	square feet

Western Dog Pens Alternative 3
Gravel, Concrete Curbs, Fence and Asphalt Removal and Disposal

Assumptions:	Quantity	Unit	Notes
All volumes are "expanded".			See note on 'WDP Volumes Details' for expansion factors.
Assumes 0% of surface gravel is Low Level Rad Waste.			
Assumes 33% of asphalt is Low Level Rad Waste.			
Assumes 50% of concrete fence posts are Low Level Rad Waste.			
Assumes 50% of concrete curbing is Low Level Rad Waste.			
Assumes 67% of dog pens have metal grating.			
Volume of gravel to be removed and disposed at sanitary landfill	1,825	cy	
Volume of asphalt to be removed and disposed at sanitary landfill	354	cy	
Volume of concrete to be removed and disposed at sanitary landfill	560	cy	
Volume of fenceposts, pipe, grating and other miscellaneous to sanitary landfill	47	cy	
Total Volume to be Disposed at Sanitary Landfill:	2,786	cy	
Volume of gravel to be removed and disposed as Low Level Rad Waste	0	cy	
Volume of asphalt to be removed and disposed as Low Level Rad Waste	175	cy	
Volume of concrete to be removed and disposed as Low Level Rad Waste	493	cy	
Volume of fenceposts, pipe, grating and other miscellaneous as Low Level Rad Waste	0	cy	
Total Volume to be Disposed as Low-Level Rad Waste:	667	cy	
Weight of gravel to be removed and disposed at sanitary landfill	2,688	ton	
Weight of asphalt to be removed and disposed at sanitary landfill	271	ton	
Weight of concrete to be removed and disposed at sanitary landfill	567	ton	
Weight of fenceposts, pipe, grating and other misc to sanitary landfill	1,805	ton	
Total Weight to be Disposed at Sanitary Landfill:	5,332	ton	
Weight of gravel to be removed and disposed as Low-Level Rad Waste	2,688	ton	
Weight of asphalt to be removed and disposed as Low-Level Rad Waste	134	ton	
Weight of concrete to be removed and disposed as Low-Level Rad Waste	499	ton	
Weight of fenceposts, pipe, grating and other miscellaneous as Low-Level Rad Waste	0	ton	
Total Weight to be Disposed as Low-Level Rad Waste	3,321	ton	

Abbreviations

cy cubic yard

Eastern Dog Pens Alternative 1
No Action

Task	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Work Plan	1	ls	$ 5,000	**$ 5,000**
Direct Capital Costs Subtotal:				**$ 5,000**
INDIRECT CAPITAL COSTS				
Project Management - 10% of total			10%	$ 1,000
Indirect Capital Costs Subtotal:				**$ 1,000**
Capital Costs Subtotal:				**$ 6,000**
ANNUAL COSTS				
Semi-Annual Site Inspection	1	ls	$ 10,000	**$ 10,000**
Annual Costs Subtotal:				**$ 10,000**
Present Worth of Annual Costs Subtotal: (At 7% for 5 years)				$ 42,000
TOTAL COSTS				
TOTAL COSTS:				**$ 48,000**

Abbreviations

ls lump sum

Eastern Dog Pens Alternative 2
Implement Institutional Controls

Task	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Work Plan	1	ls	$ 5,000	$ **5,000**
Land Use Restrictions	1	ls	$ 100,000	$ **100,000**
Install Fence	760	lf	$ 10	$ **8,000**
Direct Capital Costs Subtotal:				$ **113,000**
INDIRECT CAPITAL COSTS				
Project Management - 10% of total			10%	$ 12,000
Indirect Capital Costs Subtotal:				$ **12,000**
Capital Costs Subtotal:				$ **125,000**
ANNUAL COSTS				
Semi-Annual Site Inspection	1	ls	$ 10,000	$ **10,000**
Annual Costs Subtotal:				$ **10,000**
Present Worth of Annual Costs Subtotal: (At 7% for 5 years)				$ 42,000
TOTAL COSTS				
TOTAL COSTS:				$ **167,000**

Abbreviations

lf linear feet
ls lump sum

Eastern Dog Pens Alternative 3
Concrete Curb and Fence Removal and Disposal

Task	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Preliminary Planning Tasks				
Work Plan for Background Investigations (Concrete)	1	ls	$ 25,000	$ 25,000
Background Investigation Management and Reporting	1	ls	$ 20,000	$ 20,000
Collect Background Samples	20	ea	$ 187	$ 4,000
Background Sample Analysis Costs (Radiological Sample Suite)	20	ea	$ 1,143	$ 23,000
Sampling and Analysis Plan to Pre-Characterize Asphalt & Concrete	1	ls	$ 25,000	$ 25,000
Radiological Surface Survey Concrete Curbing	193	survey	$ 162	$ 32,000
Survey Equipment Modification Costs	1	ls	$ 15,000	$ 15,000
Collect Composite Samples	7	ea	$ 187	$ 2,000
Composite Analysis Costs (Full Suite Sample Analysis)	7	ea	$ 2,300	$ 17,000
Validate Data and Wilcoxon Rank Sum Test	1	ls	$ 20,000	$ 20,000
Risk Modeling for Exposure	1	ls	$ 20,000	$ 20,000
Submittal to DHS for Sanitary Landfill Disposal Exemption	1	ls	$ 5,000	$ 5,000
Removal Action				
Removal Action Work Plan	1	ls	$ 80,000	$ 80,000
Remove Perimeter Fencing, Install Temp Fence	760	lf	$ 10	$ 8,000
Radiological Survey of Fence	760	lf	$ 6	$ 5,000
Install Temporary Fence	760	lf	$ 2	$ 2,000
Remove Rad-Added Concrete to Roll-off Containers	180	cy	$ 23	$ 5,000
Remove Clean Concrete to Roll-off Containers	180	cy	$ 21	$ 4,000
Shipment and Disposal of Material to Envirocare	180	cy	$ 900	$ 163,000
Shipment and Disposal of Material to Landfill	859	ton	$ 60	$ 52,000
Decon Equipment	1	ls	$ 6,133	$ 7,000
Summarize Results in Dog Pens Confirmation Report	1	ls	$ 25,000	$ 25,000
Contingency - 20% of total			20%	$ 112,000
Direct Capital Costs Subtotal:				$ 671,000
INDIRECT CAPITAL COSTS				
Engineering and Design - 10% of total			10%	$ 68,000
Permitting - 5% of total			5%	$ 34,000
Project Management - 10% of total			10%	$ 68,000
Indirect Capital Costs Subtotal:				$ 170,000
Capital Costs Subtotal:				$ 841,000
ANNUAL COSTS				
Semi-Annual Site Inspection	1	ls	$ 10,000	$ 10,000
Annual Costs Subtotal:				$ 10,000
Present Worth of Annual Costs Subtotal: (At 7% for 5 years)				$ 42,000
TOTAL COSTS				
TOTAL COSTS:				$ 883,000

Abbreviations
ea each
lf linear feet
ls lump sum

Eastern Dog Pens Alternative 3
Concrete Curb and Fence Removal and Disposal

Assumptions:	Quantity	Unit	Notes
All volumes are "expanded".			See note on 'WDP Volumes Details' for expansion factors.
All values calculated from per pen values of Western Dog Pen			
Assumes 50% of concrete fence posts are Low Level Rad Waste.			
Assumes 50% of concrete curbing is Low Level Rad Waste.			
Assumes 67% of dog pens have metal grating.			
Volume of concrete to be removed and disposed at sanitary landfill	180	cy	
Volume of fenceposts, pipe, grating and other misc to sanitary landfill	17	cy	
Total Volume to be Disposed at Sanitary Landfill:	198	cy	
Volume of concrete to be removed and disposed as Low Level Rad Waste	180	cy	
Volume of fenceposts, pipe, grating and other misc as Low Level Rad Waste	0	cy	
Total Volume to be Disposed as Low-Level Rad Waste:	180	cy	
Weight of concrete to be removed and disposed at sanitary landfill	182	ton	
Weight of fenceposts, pipe, grating and other misc to sanitary landfill	677	ton	
Total Weight to be Disposed at Sanitary Landfill:	859	ton	
Weight of concrete to be removed and disposed as Low-Level Rad Waste	182	ton	
Weight of fenceposts, pipe, grating and other misc as Low-Level Rad Waste	0	ton	
Total Weight to be Disposed as Low-Level Rad Waste	182	ton	

Abbreviations

cy cubic yard

Eastern Dog Pens Alternative 4
Gravel, Concrete Curbs, Fence and Asphalt Removal and Disposal

Task	Quantity	Unit	Unit Cost	Total Cost
DIRECT CAPITAL COSTS				
Preliminary Planning Tasks				
Work Plan for Background Investigations (Concrete and Gravel)	1	ls	$ 25,000	$ 25,000
Background Investigation Management and Reporting	1	ls	$ 20,000	$ 20,000
Collect Background Samples	20	ea	$ 187	$ 4,000
Background Sample Analysis Costs (Radiological Sample Suite)	20	ea	$ 1,143	$ 23,000
Sampling and Analysis Plan to Pre-Characterize Asphalt & Concrete	1	ls	$ 25,000	$ 25,000
Radiological Surface Survey of Asphalt and Concrete Curbing	193	survey	$ 162	$ 32,000
Survey Equipment Modification Costs	1	ls	$ 15,000	$ 15,000
Collect Composite Samples	11	ea	$ 187	$ 3,000
Composite Analysis Costs (Full Suite Sample Analysis)	11	ea	$ 2,300	$ 26,000
Validate Data and Wilcoxon Rank Sum Test	1	ls	$ 20,000	$ 20,000
Risk Modeling for Exposure	1	ls	$ 20,000	$ 20,000
Submittal to DHS for Sanitary Landfill Disposal Exemption	1	ls	$ 5,000	$ 5,000
Removal Action				
Removal Action Work Plan	1	ls	$ 80,000	$ 80,000
Remove Perimeter Fencing, Install Temp Fence	760	lf	$ 10	$ 8,000
Radiological Survey of Fence	760	lf	$ 6	$ 5,000
Install Temporary Fence	760	lf	$ 2	$ 2,000
				$ -
Remove Surface Gravel to Roll-off Containers	684	cy	$ 34	$ 24,000
Remove Rad-Added Asphalt & Concrete to Roll-off Containers	241	cy	$ 23	$ 6,000
Remove Clean Asphalt & Concrete to Roll-off Containers	304	cy	$ 21	$ 7,000
Shipment and Disposal of Material to Envirocare	241	cy	$ 900	$ 218,000
Shipment and Disposal of Material to Landfill	1,962	ton	$ 60	$ 118,000
				$ -
Final Rad Survey	28	survey	$ 162	$ 5,000
Collect Confirmation Samples	70	ea	$ 89	$ 7,000
Analyze Confirmation Samples (Ra-226, Sr-90, Pesticides)	70	ea	$ 455	$ 32,000
Validate Confirmation Sample Data	1	ls	$ 10,000	$ 10,000
Import Fill, Compact and Grade	661	cy	$ 11	$ 8,000
Import Clean Fill	661	cy	$ 15	$ 10,000
Decon Equipment	1	ls	$ 6,133	$ 7,000
Summarize Results in Dog Pens Confirmation Report	1	ls	$ 25,000	$ 25,000
Contingency - 20% of total			20%	$ 158,000
Direct Capital Costs Subtotal:				$ 948,000
INDIRECT CAPITAL COSTS				
Engineering and Design - 10% of total			10%	$ 95,000
Permitting - 5% of total			5%	$ 48,000
Project Management - 10% of total			10%	$ 95,000
Indirect Capital Costs Subtotal:				$ 238,000
Capital Costs Subtotal:				$ 1,186,000
ANNUAL COSTS				
Annual Costs Subtotal:				$ -
Present Worth of Annual Costs Subtotal:				$ -
(At 7% for 5 years)				
TOTAL COSTS				
TOTAL COSTS:				$ 1,186,000

Abbreviations

cy cubic yard
ea each
lf linear feet
ls lump sum
sf square feet

Eastern Dog Pens Alternative 4
Gravel, Concrete Curbs, Fence and Asphalt Removal and Disposal

Assumptions:	Quantity	Unit	Notes
All volumes are "expanded".			See note on 'WDP Volumes Details' for expansion factors.
All values calculated from per pen values of Western Dog Pen			
Assumes 0% of surface gravel is Low Level Rad Waste.			
Assumes 33% of asphalt is Low Level Rad Waste.			
Assumes 50% of concrete fence posts are Low Level Rad Waste.			
Assumes 50% of concrete curbing is Low Level Rad Waste.			
Assumes 67% of dog pens have metal grating.			
Volume of gravel to be removed and disposed at sanitary landfill	684	cy	
Volume of asphalt to be removed and disposed at sanitary landfill	124	cy	
Volume of concrete to be removed and disposed at sanitary landfill	180	cy	
Volume of fenceposts, pipe, grating and other misc to sanitary landfill	17	cy	
Total Volume to be Disposed at Sanitary Landfill:	1,006	cy	
Volume of gravel to be removed and disposed as Low Level Rad Waste	0	cy	
Volume of asphalt to be removed and disposed at Low Level Rad Waste	61	cy	
Volume of concrete to be removed and disposed at Low Level Rad Waste	180	cy	
Volume of fenceposts, pipe, grating and other misc as Low Level Rad Waste	0	cy	
Total Volume to be Disposed as Low-Level Rad Waste:	241	cy	
Weight of gravel to be removed and disposed at sanitary landfill	1,008	ton	
Weight of asphalt to be removed and disposed at sanitary landfill	95	ton	
Weight of concrete to be removed and disposed at sanitary landfill	182	ton	
Weight of fenceposts, pipe, grating and other misc to sanitary landfill	677	ton	
Total Weight to be Disposed at Sanitary Landfill:	1,962	ton	
Weight of gravel to be removed and disposed as Low-Level Rad Waste	1,008	ton	
Weight of asphalt to be removed and disposed at Low-Level Rad Waste	47	ton	
Weight of concrete to be removed and disposed of as Low-Level Rad Waste	182	ton	
Weight of fenceposts, pipe, grating and other misc as Low-Level Rad Waste	0	ton	
Total Weight to be Disposed as Low-Level Rad Waste	1,237	ton	

Acronyms
cy cubic yard

Waste Stream		Dimensions/Pen Width (ft)	Length (ft)	Depth (ft)	Volume (CF)	No. Per Row	No. of Rows	Total Length (ft)	Total Volume (CF)	Total Volume (CY)	Total Expanded Volume (CY)	Total Weight (lbs)	Per Pen Expanded Volume (CY)	Per Pen Weight (lbs)
Concrete - Pens														
Concrete fence posts - perimeter		1.00		2.50	2	182	1		356	13	26	53,456		
Concrete fence posts - pens		1.00		2.50	6	16	16		1,634	61	121	245,044		
4" Curbing along aisles (E-W)		0.33	13	2.00	9	16	16	3,328	2,219	82	164	332,800		
6" Curbing - inside pen		0.50	29	1.00	15	16	16	7,424	3,712	137	275	556,800		
6" Curbing - around pen		0.50	17	1.00	9	16	16	4,352	2,176	81	161	326,400		
6" Curbing - perimeter		0.50	1,314	1.00	657	1	1	1,314	657	24	49	98,550		
8" Curbing - back of pens		0.67	13	1.00	9	16	16	3,328	2,219	82	164	332,800		
	Sub-Total							19,746	12,972	480	961	1,945,850	3.75	7,601
Concrete - Misc														
Concrete curbing -Cell Bio Bldg		0.50	421	2.50	0	1	1	421	0	0	0	74		
Concrete fence posts - Cell Bio Bldg		1.00		2.50	6	53	1		336	12	25	50,373		
Concrete sidewalk		5.00	545	0.33	908	1	1	545	908	34	67	136,250		
	Sub-Total							966	1,245	46	92	186,696		
	Total							20,712	14,217	527	1,053	2,132,547		
Gravel - Surface														
Inside pens		12.50	17	0.83	175	16	16		44,800	1,659	1,825	5,376,000	7.13	21,000
	Sub-Total								44,800	1,659	1,825	5,376,000		
Fence, Pipes and Grates														
Perimeter fence - 5-ft high		5.00	1,314	0.17	440	1	1	1,314	440	16	24	558,450		
Pipes, water		0.08		207.00	1	1	16	3,312	18	1	1	5,498		
Grate (Asssume 67% pens w/ grates)		12.50	17	0.01	1.46	16	16		373	14	21	3,046,400		
	Sub-Total							4,626	831	31	47	3,610,348	0.18	14,103
Asphalt														
Aisle		21.50	207	0.25	1,113	1	8	1,656	8,901	330	495	756,585	1.93	2,955
Road South of Cell Bio Bldg		12.00	207	0.25	621	1	1	207	621	23	35	52,785		
	Sub-Total							1,863	9,522	353	529	809,370		
Soil														
Beneath Aisle		21.50	207	0.25	1,113	1	8.5		9,457	350	455	898,445		
Beneath Pen		12.50	18	0.25	55	16	16		14,000	519	674	1,330,000		
	Sub-Total							0	23,457	869	1,129	2,228,445	4.41	8,705
TOTAL									92,827	3,438	4,583	14,156,709	17.90	55,300

Notes:

Material	Expand	Densities	
Soil =	1.30	95	lbs/cf
Gravel =	1.10	120	lbs/cf
Concrete =	2.00	150	lbs/cf
Fence, 5' chain link =	2.00	2.00	lbs/sf
Asphalt=	1.50	85	lbs/cf
Steel Pipe, 1"=	2.00	1.66	lbs/ft

Assume no liquid waste will be generated. Per Pen values used to calculate volumes in Eastern Dog Pens.

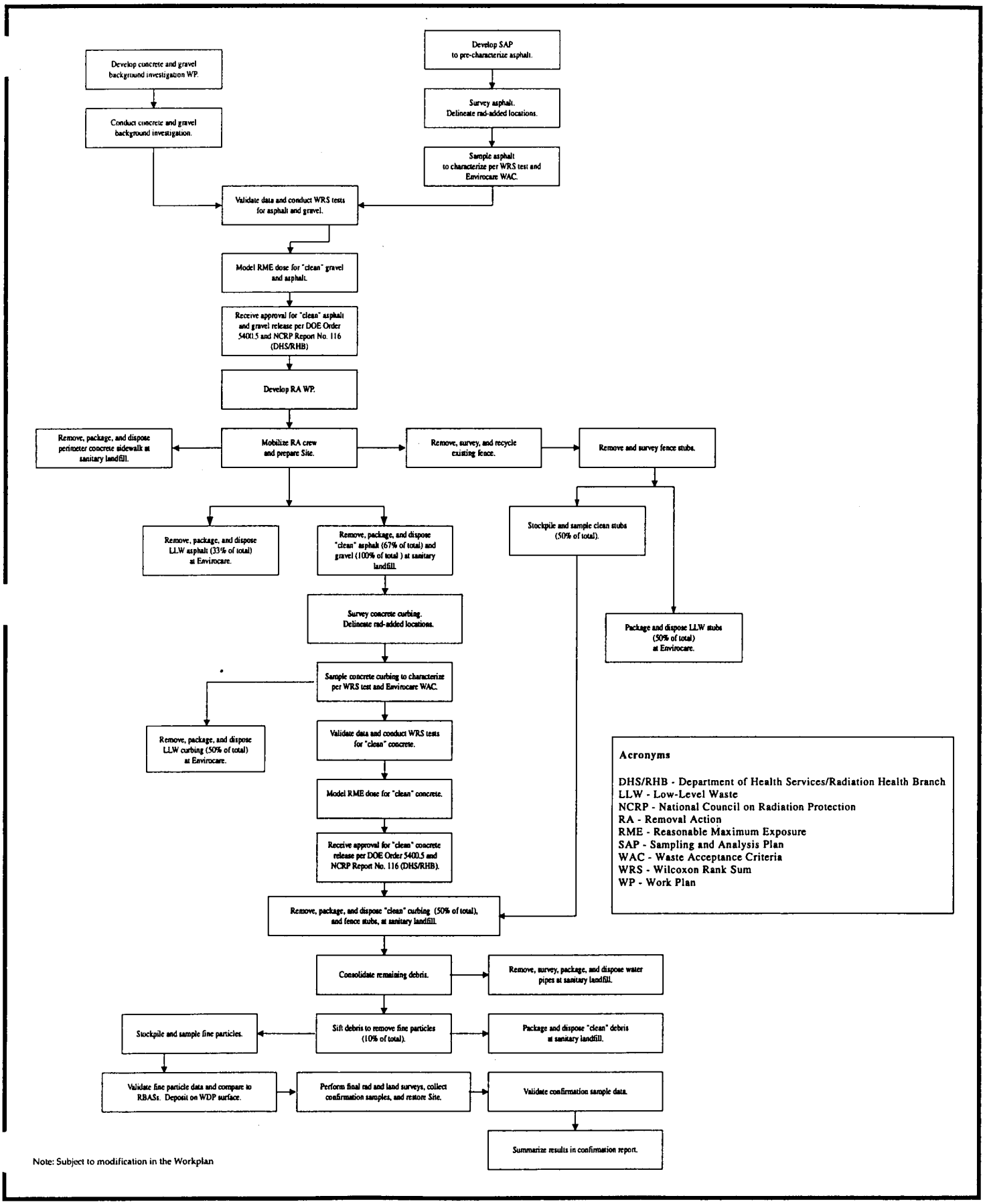

Figure A-1. Assumed Process Steps for Western Dog Pens Alternative 3

Weiss Associates

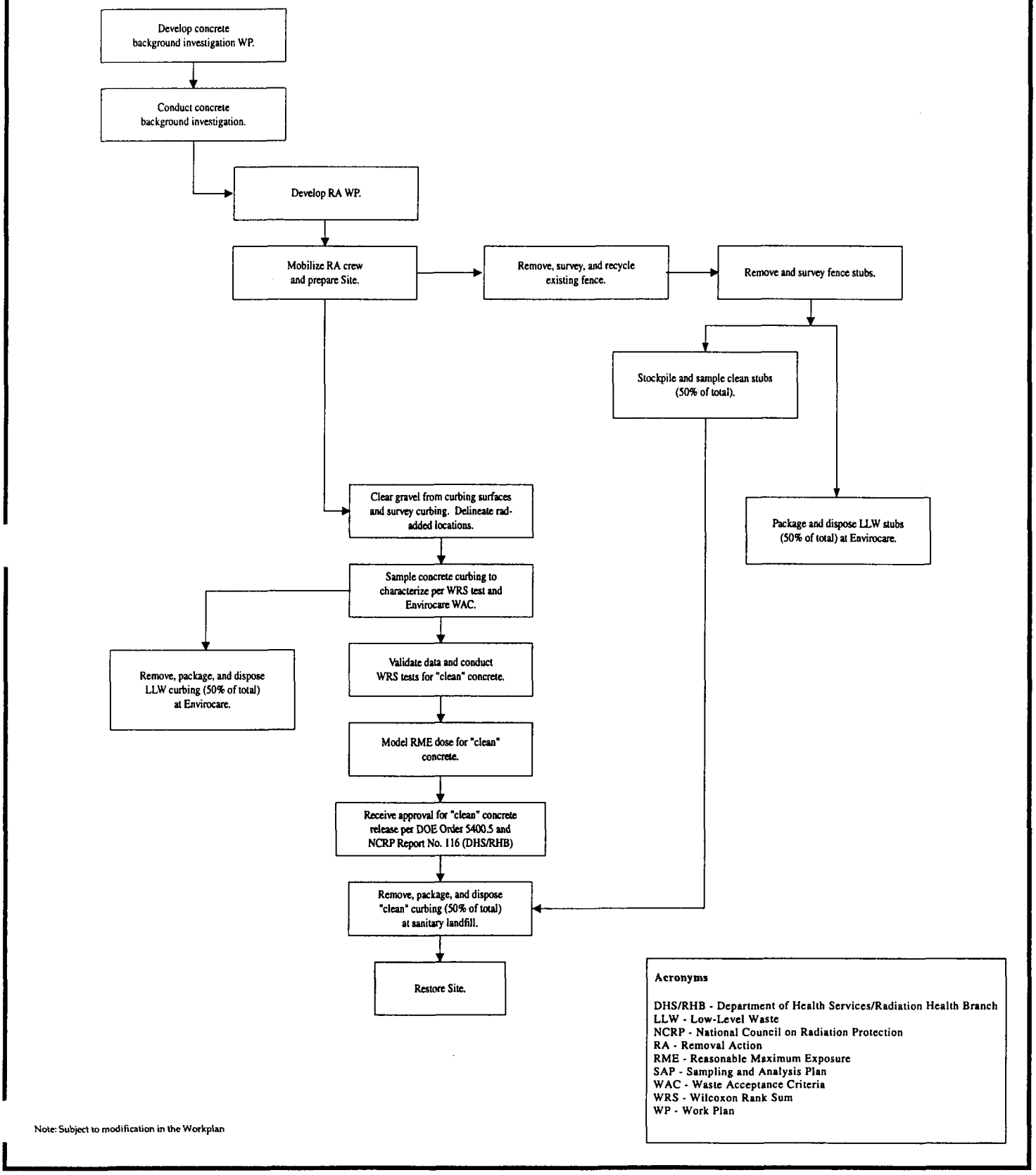

Figure A-2. Assumed Process Steps for Eastern Dog Pens Alternative 3

Weiss Associates

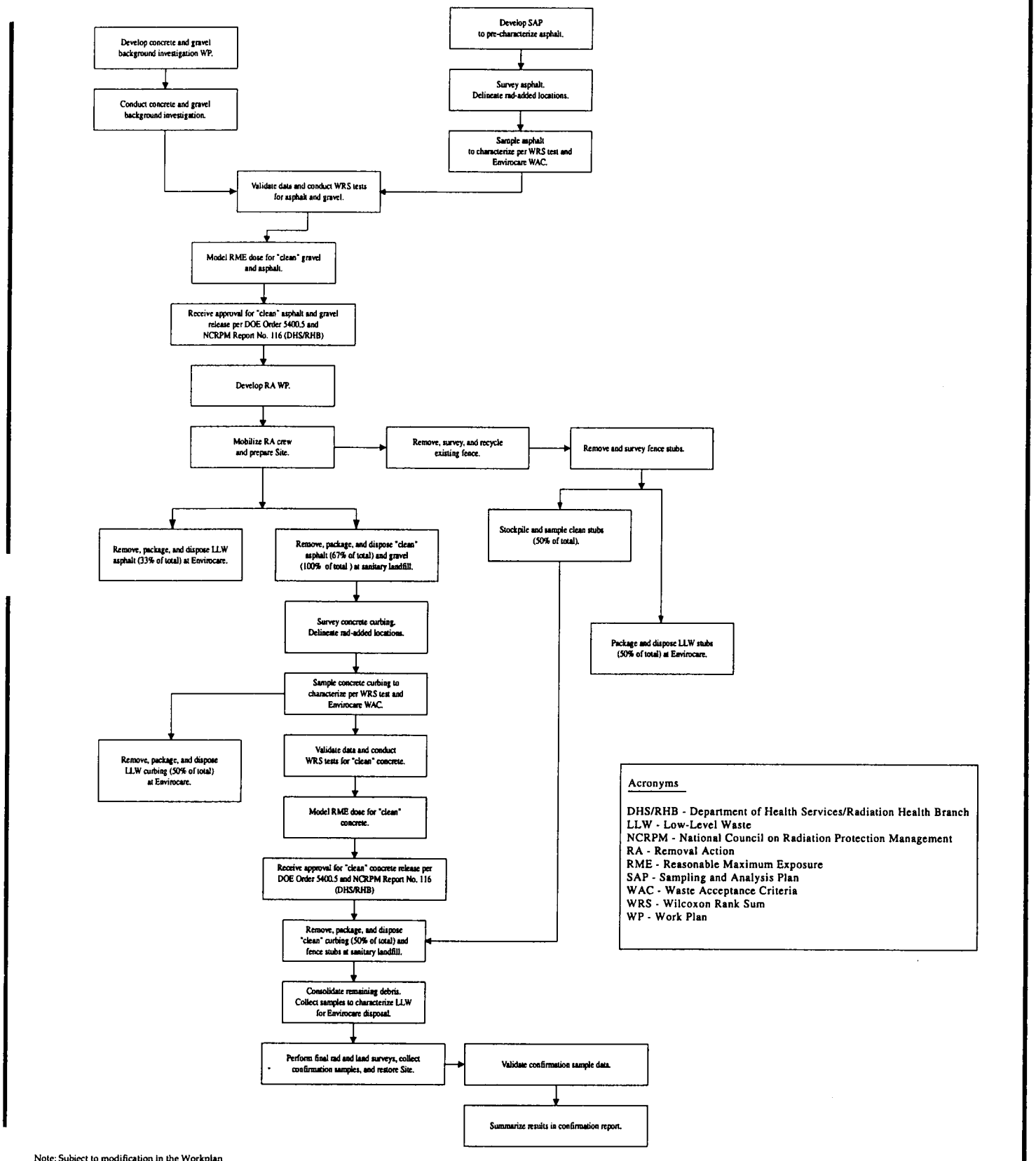

Figure A-3. Assumed Process Steps for Eastern Dog Pens Alternative 4

APPENDIX B

SUMMARY OF ON-SITE HABITATS AND POTENTIAL ECOLOGICAL RECEPTORS

Table B-1. Summary of On-Site Habitats and Potential Ecological Receptors[1]

Habitat Type	Area (% of Site)	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
Ruderal/Non-native Grassland	222,400 sf 5.1 acres (27%)					
		Amphibian				
			Western Toad	-	uncommon	none
			Pacific Tree Frog	-	common	none
		Bats				
			Big Brown Bat	-	uncommon	none
			California Myotis	-	uncommon	none
		Burrowing Mammal				
			CA Ground Squirrel	x	common	none
			CA Vole	-	common	none
			House Mouse	-	common	none
			W. Harvest Mouse	-	uncommon	none
			Bottas Pocket Gopher	x	common	none
			Black-tailed Jackrabbit	x	common	none
			Audubon's Cottontail	x	common	none
		Granivorous Bird				
			Mourning Dove	x	common	MB
			House Finch	x	common	MB
			Rock Dove	x	common	MB
			Golden-crowned Sparrow	x	common	MB
			White-crowned Sparrow	x	common	MB
		Insectivorous Bird				
			Black Phoebe	x	common	none
		Omnivorous Bird				
			Red-winged Blackbird	-	common	MB
			Hermit Thrush	x	uncommon	MB
			Killdeer	x	common	MB
			American Crow	x	common	MB
			CA Horned Lark	**x**	**uncommon**	**SC,MB/ SSC**
			Brewer's Blackbird	x	common	MB
			Dark-eyed Junco	x	common	MB

Table B-1. Summary of On-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Area (% of Site)	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
Ruderal/Non-native Grassland (continued)			California Towhee	x	common	none
			Western Meadowlark	x	common	MB
			European Starling	x	common	none
			American Robin	x	common	MB
		Predatory Mammal				
			Coyote	x	uncommon	none
			Opossum	-	uncommon	none
			Striped Skunk	x	common	none
			Raccoon	x	common	none
			Red Fox	-	uncommon	none
			Gray Fox	-	uncommon	MB
		Raptor	**Short-eared Owl**	**-**	**uncommon**	**MB/SSC**
			Great Horned Owl	x	uncommon	MB
			Barn Owl	x	uncommon	MB
			Red-tailed Hawk	x	common	MB
			Northern Harrier	**x**	**common**	**MB/SSC**
			White-tailed Kite	x	common	MB*
			American Kestrel	x	common	MB
		Reptile				
			Gopher Snake	-	uncommon	none
			Western Fence Lizard	-	common	none
	61,300 sf 1.4 acres (26%)	Granivorous Bird				
			House Finch	x	common	MB
			Hermit Thrush	x	uncommon	MB
			Rock Dove	x	common	none
			Golden-crowned Sparrow	x	common	MB
			White-crowned Sparrow	x	common	MB
			Red Crossbill	x	uncommon	MB
			Mourning Dove	x	common	MB/-
		Insectivorous Bird				
			Northern Flicker	x	uncommon	MB
			Ruby-crowned Kinglet	x	common	MB
			Black Phoebe	x	common	MB
			Red-breasted Nuthatch	x	uncommon	MB
			House Wren	x	uncommon	MB

Table B-1. Summary of On-Site Habitats and Potential Ecological Receptors[1] (continued)

Ruderal/Non-native Grassland (continued)		Omnivorous Bird				
			Anna's Hummingbird	x	Common	MB
			Scrub Jay	x	common	MB
			American Crow	x	common	MB
			California Towhee	x	common	none
			Western Meadowlark	x	common	MB
			European Starling	x	common	none
			American Robin	x	common	MB
			Yellow-rumped Warbler	x	common	MB
			Dark-eyed Junco	x	common	MB
			Yellow-billed Magpie	x	common	MB
			Rufous-sided Towhee	x	uncommon	MB
		Raptor				
			Coopers Hawk	x	uncommon	MB/SSC
			Great Horned Owl	x	uncommon	MB
			Barn Owl	x	uncommon	MB
			Red-tailed Hawk	x	common	MB
			American Kestrel	x	uncommon	MB
Buildings and Structures	100,900 sf, 2.3 acres, (12%)					
		Bats				
			Townsend's Big-eared Bat	-	uncommon	SC/SSC
			Pallid Bat	-	uncommon	SSC
			California Mastiff Bat	-	uncommon	SC/SSC
			Big Brown Bat	-	common	none
			California Myotis	-	common	none
		Granivorous Bird				
			House Finch	x	common	MB
			House Sparrow	-	common	none
			Rock Dove	x	common	none
		Raptor	Barn Owl	x	common	MB

Table B-1. Summary of On-Site Habitats and Potential Ecological Receptors[1] (continued)

Notes:

- = Expected Species
x = Observed Species
a = Terrestrial invertebrate species not listed, not in scope of site reconnaissance
TEXT = Special status species, likely representative species selection
(1) Source: Draft Ecological Scoping Assessment for the DOE Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, Weiss Associates, July 9, 1997. Pages 4-17 to 4-30.
FE = Listed as Endangered by the Federal Government
FT = Listed as Threatened by the Federal Government
SC = Species of Concern
MB = Migratory non-game birds of management concern to the USFWS; protected under the Migratory Bird Treaty Act
CE = Listed as Endangered by the State of California
CT = Listed as Threatened by the State of California
SSC = California Species of Special Concern
* = Taxa that are restricted in distribution, declining throughout their range, or associated with habitats that are declining in California

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1]

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
Ruderal/Non-native Grassland					
	Amphibian				
		Western Toad	-	uncommon	none
		Pacific Tree Frog	-	common	none
	Bats				
		Big Brown Bat	-	uncommon	none
		California Myotis	-	uncommon	none
	Burrowing Mammal				
		CA Ground Squirrel	x	common	none
		CA Vole	-	common	none
		House Mouse	-	common	none
		W. Harvest Mouse	-	uncommon	none
		Bottas Pocket Gopher	x	common	none
		Black-tailed Jackrabbit	x	common	none
		Audubon's Cottontail	x	common	none
	Burrowing Owl				
		Burrowing Owl	x	**uncommon**	**SC, MB/SSC**
	Granivorous Bird				
		Mourning Dove	x	common	MB
		House Finch	x	common	MB
		Rock Dove	x	common	MB
		Golden-crowned Sparrow	x	common	MB
		White-crowned Sparrow	x	common	MB
	Insectivorous Bird				
		Black Phoebe	x	common	none
	Omnivorous Bird				
		Red-winged Blackbird	-	common	MB
		Hermit Thrush	x	uncommon	MB
		Killdeer	x	common	MB
		American Crow	x	common	MB
		CA Horned Lark	x	**uncommon**	**SC,MB/SS**

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
					C
		Brewer's Blackbird	x	common	MB
		Dark-eyed Junco	x	common	MB
		California Towhee	x	common	none
		Western Meadowlark	x	common	MB
		European Starling	x	common	none
		American Robin	x	common	MB
	Predatory Mammal				
		Coyote	x	uncommon	none
		Opossum	-	uncommon	none
		Striped Skunk	x	common	none
		Raccoon	x	common	none
		Red Fox	-	uncommon	none
		Gray Fox	-	uncommon	MB
	Raptor				
		Short-eared Owl	**-**	**uncommon**	**MB/SSC**
		Great Horned Owl	x	uncommon	MB
		Barn Owl	x	uncommon	MB
		Red-tailed Hawk	x	common	MB
		Northern Harrier	**x**	**common**	**MB/SSC**
		White-tailed Kite	x	common	MB*
		American Kestrel	x	common	MB
	Reptile				
		Gopher Snake	-	uncommon	none
		Western Fence Lizard	-	common	none
Ruderal/ Landscaped-Ornamental Trees	Granivorous Bird				
		House Finch	x	common	MB
		Hermit Thrush	x	uncommon	MB
		Rock Dove	x	common	none
		Golden-crowned Sparrow	x	common	MB
		White-crowned Sparrow	x	common	MB
		Red Crossbill	x	uncommon	MB
		Mourning Dove	x	common	MB/-

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
	Insectivorous Bird				
		Northern Flicker	x	uncommon	MB
		Ruby-crowned Kinglet	x	common	MB
		Black Phoebe	x	common	MB
		Red-breasted Nuthatch	x	uncommon	MB
		House Wren	x	uncommon	MB
	Omnivorous Bird				
		Anna's Hummingbird	x	common	MB
		Scrub Jay	x	common	MB
		American Crow	x	common	MB
		California Towhee	x	common	none
		Western Meadowlark	x	common	MB
		European Starling	x	common	none
		American Robin	x	common	MB
		Yellow-rumped Warbler	x	common	MB
		Dark-eyed Junco	x	common	MB
		Yellow-billed Magpie	x	common	MB
		Rufous-sided Towhee	x	uncommon	MB
	Raptor				
		Coopers Hawk	x	uncommon	MB/SSC
		Great Horned Owl	x	uncommon	MB
		Barn Owl	x	uncommon	MB
		Red-tailed Hawk	x	common	MB
		American Kestrel	x	uncommon	MB
Buildings and Structures					
	Bats				
		Townsend's Big-eared Bat	-	uncommon	SC/SSC
		Pallid Bat	-	uncommon	SSC
		California Mastiff Bat	-	uncommon	SC/SSC

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
		Big Brown Bat	-	common	none
		California Myotis	-	common	none
	Granivorous Bird				
		House Finch	x	common	MB
		House Sparrow	-	common	none
		Rock Dove	x	common	none
	Raptor	Barn Owl	x	common	MB
Cultivated Fields and Orchards	Burrowing Mammal				
		Bottas Pocket Gopher	x	common	none
		Black-tailed Jackrabbit	x	common	none
		Audubon's Cottontail	x	common	none
	Granivorous Bird				
		Golden-crowned Sparrow	x	common	MB
		White-crowned Sparrow	x	common	MB
	Omnivorous Bird				
		Red-winged Blackbird	-	common	MB
		Tricolored Blackbird	**-**	**uncommon**	**MB/SSC**
		Killdeer	x	common	MB
		American Crow	x	common	MB
		CA Horned Lark	**x**	**uncommon**	**MB/SSC**
		Brewer's Blackbird	x	common	MB
		Yellow-billed Magpie	x	common	MB
		Western Meadowlark	x	common	MB
		American Robin	x	common	MB
	Predatory Mammal				
		Striped Skunk	x	common	none
		Coyote	x	uncommon	none
	Raptor				
		Red-tailed Hawk	x	common	MB
		Northern Harrier	**x**	**common**	**MB/SSC**
		White-tailed Kite	**x**	**common**	**MB/SSC**
		American Kestrel	x	common	MB

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
Great Valley Mixed Riparian Forest	Reptile	Gopher Snake	-	uncommon	none
		Western Fence Lizard	-	common	none
	Amphibian	Western Toad	-	uncommon	none
		Pacific Treefrog	-	common	none
	Aquatic Mammal	Beaver	x	common	none
		River Otter	-	uncommon	none
	Bats	Big Brown Bat	-	common	none
		Western Red Bat	-	uncommon	none
		California Myotis	-	uncommon	none
		Yuma Myotis	-	uncommon	none
	Burrowing Mammal	California Vole	-	common	none
		House Mouse	-	common	none
		Deer Mouse	-	common	none
		Western Harvest Mouse	-	common	none
		Audubon's Cottontail	x	common	none
	Granivorous Bird	California Quail	x	common	none
		American Goldfinch	-	common	MB
		Lesser Goldfinch	x	common	MB
		Lark Sparrow	-	common	MB
		Lincoln's Sparrow	-	uncommon	MB
		Song Sparrow	x	common	MB
		Black-headed Grosbeak	-	uncommon	MB
		Chipping Sparrow	-	uncommon	MB
		Mourning Dove	-	common	MB
		Golden-crowned Sparrow	-	common	MB
		White-crowned Sparrow	-	common	MB
	Herbivorous Mammal	Mule Deer	-	uncommon	none
	Insectivorous Bird	Killdeer	x	common	MB

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
		Marsh Wren	-	uncommon	MB
Great Valley Mixed Riparian Forest (continued)		Northern Flicker	x	common	MB
		Cliff Swallow	-	common	MB
		Acorn Woodpecker	-	uncommon	MB
		Ash-throated Flycatcher	-	uncommon	MB
		Nuttall's Woodpecker	x	common	MB
		Downy Woodpecker	-	uncommon	MB
		Barn Swallow	x	common	MB
		Red-breasted Nuthatch	x	common	MB
		No. Rough-winged Swallow	-	common	MB
		Tree Swallow	-	uncommon	MB
		Violet-green Swallow	-	common	MB
		Bewick's Wren	-	common	MB
		House Wren	x	common	MB
	Omnivorous Bird				
		Loggerhead Shrike	-	**uncommon**	**MB/SSC**
		Plain Titmouse	-	common	MB
		Anna's Hummingbird	-	Common	MB
		Scrub Jay	x	common	MB
		Hermit Thrush	x	uncommon	MB
		American Crow	x	common	MB
		Yellow-rumped Warbler	x	common	MB
		Black-throated Gray Warbler	-	uncommon	MB
		Brewer's Blackbird	x	common	MB
		Northern Oriole	-	common	MB
		Varied Thrush	-	uncommon	MB
		Dark-eyed Junco	x	common	MB
		California Gull	x	common	MB
		Ring-billed Gull	-	uncommon	MB
		Northern Mockingbird	-	common	MB
		Brown-headed Cowbird	-	common	MB
		Lazuli Bunting	-	common	MB
		Ring-necked Pheasant	-	uncommon	none
		Yellow-billed	x	common	MB

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
		Magpie			
		California Towhee	x	common	none
Great Valley Mixed Riparian Forest (continued)		Rufous-sided Towhee	x	uncommon	MB
		Bushtit	-	common	MB
		Ruby-crowned Kinglet	x	common	MB
		Black Phoebe	x	common	MB
		Pays Phoebe	x	common	MB
		Mountain Bluebird	-	common	MB
		Western Bluebird	-	uncommon	MB
		European Starling	x	common	none
		American Robin	x	common	MB
		Western Kingbird	-	uncommon	MB
		Orange-crowned Warbler	-	common	MB
		Wilson's Warbler	-	common	MB
	Piscivorous Bird				
		Belted Kingfisher	x	uncommon	MB
		Forster's Tern	-	common	MB
	Wading Shore Bird				
		Green-backed Heron	-	uncommon	MB
		Common Snipe	-	uncommon	MB
		Great Egret	x	uncommon	MB
		Snowy Egret	x	common	MB
		Black-crowned Night Heron	x	common	MB
	Predatory Mammal				
		American Badger	-	uncommon	*
		Coyote	x	common	none
		Opossum	-	common	none
		Bobcat	-	uncommon	none
		Striped Skunk	x	common	none
		Long-tailed Weasel	-	uncommon	none
		Raccoon	x	common	none
		Ornate Shrew	-	uncommon	none
		Spotted Skunk	-	uncommon	none
		Gray Fox	-	uncommon	none
		Red Fox	-	uncommon	none

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
Great Valley Mixed Riparian Forest (continued)	Raptor				
		Coopers Hawk	**x**	**uncommon**	**MB/SSC**
		Sharp-shinned Hawk	**-**	**uncommon**	**MB/SSC**
		Golden Eagle	**-**	**uncommon**	**MB/SSC**
		Great Horned Owl	x	uncommon	MB
		Red-tailed Hawk	x	common	MB
		Red-shouldered Hawk	-	uncommon	MB
		Northern Harrier	**x**	**common**	**MB/SSC**
		White-tailed Kite	**x**	**common**	**MB/SSC**
		Merlin	**-**	**uncommon**	**MB/SSC**
		American Kestrel	x	common	MB
		Western Screech-owl	-	uncommon	MB
		Barn Owl	x	common	MB
	Reptile				
		Western Pond Turtle	**-**	**uncommon**	**SC/SSC**
		Racer	-	uncommon	none
		Gilbert's Skink	-	uncommon	none
		Southern Alligator Lizard	-	uncommon	none
		Common Kingsnake	-	uncommon	none
		Gopher Snake	-	uncommon	none
		Western Fence Lizard	-	common	none
		Western Terrestrial Garter Snake	-	common	none
		Giant Garter Snake	**-**	**uncommon**	**FT/CT**
		Side-blotched Lizard	-	common	none
	Water Fowl				
		Wood Duck	-	uncommon	MB
		Northern Pintail	-	uncommon	MB
		American Widgeon	-	uncommon	MB
		Green-winged Teal	-	uncommon	MB
		Northern Shoveler	-	uncommon	MB
		Cinnamon Teal	-	uncommon	MB
		Mallard	x	common	MB
		Gadwall	-	uncommon	MB
		Greater White-fronted Goose	-	uncommon	MB

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
		Lesser Scaup	-	uncommon	MB
		Ring-necked Duck	-	uncommon	MB
		Canada Goose	x	uncommon	MB
		Common Goldeneye	-	uncommon	MB
Great Valley Mixed Riparian Forest (continued)		American Coot	x	common	MB
		Common Moorhen	-	uncommon	MB
		Black-necked Stilt	-	uncommon	MB
		Common Yellowthroat	-	uncommon	MB
	Water Fowl (continued)	Black-bellied Plover	-	uncommon	MB
		Common Merganser	-	uncommon	MB
		Bufflehead	-	uncommon	MB
	Wading Shore Bird				
		Western Sandpiper	-	common	MB
		Least Sandpiper	-	common	MB
		Virginia Rail	-	uncommon	MB
		American Avocet	-	uncommon	MB
		Greater Yellowlegs	-	uncommon	MB
		Spotted Sandpiper	-	uncommon	MB
		Long-billed Curlew	**-**	**uncommon**	**MB/SSC**
		Sora	-	uncommon	MB
		Great Blue Heron	**x**	**uncommon**	**MB/***
		Pied-billed Grebe	x	uncommon	MB
		Double-crested Cormorant	-	uncommon	MB
Creek	Benthic/Pelagic Invertebrates[b]				
		Diptera (family chronomide)	-	NA	none
		Trichoptera (family lepidostomatidai)	-	NA	none
		Oligocheata	-	NA	none
		Tubellaria	-	NA	none
		GasTrapoda	-	NA	none
		Amphipoda	-	NA	none
		Mollusca	-	NA	none
		Crustacea - crayfish	-	NA	none
	Fish				
		Pacific Lamprey	**-**	**uncommon**	**SC**
		Hitch	-	common	none

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors(1) (continued)

Habitat Type	Exposure Group[a]	Expected Species	Observed Species	Relative Occurrence	Fed/CA Status
		Sacramento Blackfish	-	common	none
		American Shad	-	uncommon	none
		White Catfish	-	common	none
		Common Carp	-	common	none
Creek (continued)	Fish (continued)	Black Bullhead	-	common	none
		Channel Catfish	-	common	none
		Green Sunfish	-	common	none
		White Crappie	-	common	none
		Sacramento Sucker	-	NA	none
		Three-spined Stickleback	-	NA	none
		Tule Perch	-	NA	none
		Sacramento Squawfish	-	NA	none
		Threadfin Shad	-	NA	none
		Mosquitofish	-	NA	none
		Brown Bullhead	-	NA	none
		Bluegill	-	NA	none
		Redear Sunfish	-	NA	none
		Mississippi Silverside	-	NA	none
		Golden Shiner	-	NA	none
		Bigscale Logperch	-	NA	none
		Fathead Minnow	-	NA	none
		Black Crappie	-	NA	none
	Predatory Fish	Rainbow Trout	-	uncommon	None
		Chinook Salmon	-	uncommon	FE/CE
		Smallmouth Bass	-	common	none
		Largemouth Bass	-	common	none
		Striped Bass	-	NA	none

Notes:

- = Expected Species
x = Observed Species
[a] = Terrestrial invertebrate species not listed, not in scope of site reconnaissance
[b] = Data not available due to exceedingly heavy rainfall and record-breaking floods, water levels in Putah Creek were too high to effectively conduct fish and benthic/pelagic invertebrate studies. Expected species list generated from personal communication with UC Davis research staff and published literature
TEXT = Special status species, likely representative species selection.
(1) Source: Draft Ecological Scoping Assessment for DOE Areas for the DOE Areas at the Laboratory for Energy-Related Health Research, University of California at Davis, California, Weiss Associates, July 9, 1997. Pages 4-17 to 4-30.
FE = Listed as Endangered by the Federal Government
FT = Listed as Threatened by the Federal Government
SC = Species of Concern
MB = Migratory non-game birds of management concern to the USFWS; protected under the Migratory Bird Treaty Act
CE = Listed as Endangered by the State of California

Table B-2. Summary of Off-Site Habitats and Potential Ecological Receptors[1] (continued)

CT = Listed as Threatened by the State of California
SSC = California Species of Special Concern
* = Taxa that are restricted in distribution, declining throughout their range, or associated with habitats that are declining in California

APPENDIX C

LIST OF ENDANGERED AND THREATENED SPECIES THAT MAY BE PRESENT AT THE LEHR SITE

ENCLOSURE A

Endangered and Threatened Species that May Occur in
or be Affected by Projects in the Selected Quads Listed Below
Reference File No. 1-1-00-SP-1225
Remediation Activities at Laboratory for Energy-Related Health Research, Davis, California
March 21, 2000

QUAD : 513C DAVIS

Listed Species

Birds

Aleutian Canada goose, *Branta canadensis leucopareia* (T)

bald eagle, *Haliaeetus leucocephalus* (T)

Reptiles

giant garter snake, *Thamnophis gigas* (T)

Amphibians

California red-legged frog, *Rana aurora draytonii* (T)

Fish

delta smelt, *Hypomesus transpacificus* (T)

Central Valley steelhead, *Oncorhynchus mykiss* (T)

winter-run chinook salmon, *Oncorhynchus tshawytscha* (E)

Central Valley spring-run chinook salmon, *Oncorhynchus tshawytscha* (T)

Sacramento splittail, *Pogonichthys macrolepidotus* (T)

Invertebrates

vernal pool fairy shrimp, *Branchinecta lynchi* (T)

valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

vernal pool tadpole shrimp, *Lepidurus packardi* (E)

Proposed Species

Birds

mountain plover, *Charadrius montanus* (PT)

Candidate Species

Amphibians

California tiger salamander, *Ambystoma californiense* (C)

Fish

Central Valley fall/late fall-run chinook salmon, *Oncorhynchus tshawytscha* (C)

Species of Concern

Mammals

Pacific western big-eared bat, *Corynorhinus (=Plecotus) townsendii townsendii* (SC)

small-footed myotis bat, *Myotis ciliolabrum* (SC)

long-eared myotis bat, *Myotis evotis* (SC)

fringed myotis bat, *Myotis thysanodes* (SC)

long-legged myotis bat, *Myotis volans* (SC)

Yuma myotis bat, *Myotis yumanensis* (SC)

San Joaquin pocket mouse, *Perognathus inornatus* (SC)

Birds

tricolored blackbird, *Agelaius tricolor* (SC)

western burrowing owl, *Athene cunicularia hypugea* (SC)

Swainson's hawk, *Buteo Swainsoni* (CA)

ferruginous hawk, *Buteo regalis* (SC)

little willow flycatcher, *Empidonax traillii brewsteri* (CA)

American peregrine falcon, *Falco peregrinus anatum* (D)

greater sandhill crane, *Grus canadensis tabida* (CA)

white-faced ibis, *Plegadis chihi* (SC)

bank swallow, *Riparia riparia* (CA)

Reptiles

northwestern pond turtle, *Clemmys marmorata marmorata* (SC)

California horned lizard, *Phrynosoma coronatum frontale* (SC)

Amphibians

western spadefoot toad, *Scaphiopus hammondii* (SC)

Fish

green sturgeon, *Acipenser medirostris* (SC)

river lamprey, *Lampetra ayresi* (SC)

Pacific lamprey, *Lampetra tridentata* (SC)

longfin smelt, *Spirinchus thaleichthys* (SC)

Invertebrates

Antioch Dunes anthicid beetle, *Anthicus antiochensis* (SC)

Sacramento anthicid beetle, *Anthicus sacramento* (SC)

California linderiella fairy shrimp, *Linderiella occidentalis* (SC)

Plants

alkali milk-vetch, *Astragalus tener var. tener* (SC) *

QUAD : 514D MERRITT

Listed Species

Birds

Aleutian Canada goose, *Branta canadensis leucopareia* (T)

bald eagle, *Haliaeetus leucocephalus* (T)

Reptiles

giant garter snake, *Thamnophis gigas* (T)

Amphibians

California red-legged frog, *Rana aurora draytonii* (T)

Fish

delta smelt, *Hypomesus transpacificus* (T)

Central Valley steelhead, *Oncorhynchus mykiss* (T)

winter-run chinook salmon, *Oncorhynchus tshawytscha* (E)

Central Valley spring-run chinook salmon, *Oncorhynchus tshawytscha* (T)

Sacramento splittail, *Pogonichthys macrolepidotus* (T)

Invertebrates

vernal pool fairy shrimp, *Branchinecta lynchi* (T)

valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

vernal pool tadpole shrimp, *Lepidurus packardi* (E)

Proposed Species

Birds

mountain plover, *Charadrius montanus* (PT)

Fish

Critical Habitat, Central Valley spring-run chinook, *Oncorhynchus tshawytscha* (PX)

Candidate Species

Amphibians

California tiger salamander, *Ambystoma californiense* (C)

Fish

Central Valley fall/late fall-run chinook salmon, *Oncorhynchus tshawytscha* (C)

Species of Concern

Mammals

Pacific western big-eared bat, *Corynorhinus (=Plecotus) townsendii townsendii* (SC)

small-footed myotis bat, *Myotis ciliolabrum* (SC)

long-eared myotis bat, *Myotis evotis* (SC)

fringed myotis bat, *Myotis thysanodes* (SC)

long-legged myotis bat, *Myotis volans* (SC)

Yuma myotis bat, *Myotis yumanensis* (SC)

San Joaquin pocket mouse, *Perognathus inornatus* (SC)

Birds

tricolored blackbird, *Agelaius tricolor* (SC)

western burrowing owl, *Athene cunicularia hypugea* (SC)

Swainson's hawk, *Buteo Swainsoni* (CA)

ferruginous hawk, *Buteo regalis* (SC)

little willow flycatcher, *Empidonax traillii brewsteri* (CA)

American peregrine falcon, *Falco peregrinus anatum* (D)

greater sandhill crane, *Grus canadensis tabida* (CA)

white-faced ibis, *Plegadis chihi* (SC)

bank swallow, *Riparia riparia* (CA)

Reptiles

northwestern pond turtle, *Clemmys marmorata marmorata* (SC)

Amphibians

western spadefoot toad, *Scaphiopus hammondii* (SC)

Fish

green sturgeon, *Acipenser medirostris* (SC)

river lamprey, *Lampetra ayresi* (SC)

Pacific lamprey, *Lampetra tridentata* (SC)

longfin smelt, *Spirinchus thaleichthys* (SC)

Invertebrates

California linderiella fairy shrimp, *Linderiella occidentalis* (SC)

Plants

alkali milk-vetch, *Astragalus tener var. tener* (SC) *

KEY:

(E)	*Endangered*	Listed (in the Federal Register) as being in danger of extinction.
(T)	*Threatened*	Listed as likely to become endangered within the foreseeable future.
(P)	*Proposed*	Officially proposed (in the Federal Register) for listing as endangered or threatened.
(PX)	*Proposed Critical Habitat*	Proposed as an area essential to the conservation of the species.
(C)	*Candidate*	Candidate to become a *proposed* species.
(SC)	*Species of Concern*	May be endangered or threatened. Not enough biological information has been gathered to support listing at this time.
(D)	*Delisted*	Delisted. Status to be monitored for 5 years.
(CA)	*State-Listed*	Listed as threatened or endangered by the State of California.
(*)	*Extirpated*	Possibly extirpated from this quad.
(**)	*Extinct*	Possibly extinct.
	Critical Habitat	Area essential to the conservation of a species.

Endangered and Threatened Species that May Occur in or be Affected by
PROJECTS IN YOLO COUNTY
Reference File No. 1-1-00-SP-1225
March 21, 2000

Listed Species

Birds

Aleutian Canada goose, *Branta canadensis leucopareia* (T)
bald eagle, *Haliaeetus leucocephalus* (T)
northern spotted owl, *Strix occidentalis caurina* (T)

Reptiles

giant garter snake, *Thamnophis gigas* (T)

Amphibians

California red-legged frog, *Rana aurora draytonii* (T)

Fish

Critical habitat, winter-run chinook salmon, *Oncorhynchus tshawytscha* (E)
winter-run chinook salmon, *Oncorhynchus tshawytscha* (E)
Critical habitat, delta smelt, *Hypomesus transpacificus* (T)
delta smelt, *Hypomesus transpacificus* (T)
Central Valley steelhead, *Oncorhynchus mykiss* (T)
Central Valley spring-run chinook salmon, *Oncorhynchus tshawytscha* (T)
Sacramento splittail, *Pogonichthys macrolepidotus* (T)

Invertebrates

Conservancy fairy shrimp, *Branchinecta conservatio* (E)
vernal pool tadpole shrimp, *Lepidurus packardi* (E)
vernal pool fairy shrimp, *Branchinecta lynchi* (T)
valley elderberry longhorn beetle, *Desmocerus californicus dimorphus* (T)

Plants

palmate-bracted bird's-beak, *Cordylanthus palmatus* (E)
Solano grass, *Tuctoria mucronata* (E)
Colusa grass, *Neostapfia colusana* (T)

Proposed Species

Birds

mountain plover, *Charadrius montanus* (PT)

Fish

Critical Habitat, Central Valley spring-run chinook, *Oncorhynchus tshawytscha* (PX)

Candidate Species

Amphibians

California tiger salamander, *Ambystoma californiense* (C)

Species of Concern

Mammals

Pacific western big-eared bat, *Corynorhinus (=Plecotus) townsendii townsendii* (SC)
greater western mastiff-bat, *Eumops perotis californicus* (SC)
small-footed myotis bat, *Myotis ciliolabrum* (SC)
long-eared myotis bat, *Myotis evotis* (SC)
fringed myotis bat, *Myotis thysanodes* (SC)
long-legged myotis bat, *Myotis volans* (SC)
Yuma myotis bat, *Myotis yumanensis* (SC)
San Joaquin pocket mouse, *Perognathus inornatus* (SC)

Birds

little willow flycatcher, *Empidonax traillii brewsteri* (CA)
greater sandhill crane, *Grus canadensis tabida* (CA)
bank swallow, *Riparia riparia* (CA)
American peregrine falcon, *Falco peregrinus anatum* (D)
grasshopper sparrow, *Ammodramus savannarum* (SC)
short-eared owl, *Asio flammeus* (SC)
western burrowing owl, *Athene cunicularia hypugea* (SC)
American bittern, *Botaurus lentiginosus* (SC)
ferruginous hawk, *Buteo regalis* (SC)
Lawrence's goldfinch, *Carduelis lawrencei* (SC)
Vaux's swift, *Chaetura vauxi* (SC)
black tern, *Chlidonias niger* (SC)
lark sparrow, *Chondestes grammacus* (SC)
olive-sided flycatcher, *Contopus cooperi* (SC)
hermit warbler, *Dendroica occidentalis* (SC)
white-tailed (=black shouldered) kite, *Elanus leucurus* (SC)
common loon, *Gavia immer* (SC)
least bittern, western, *Ixobrychus exilis hesperis* (SC)
loggerhead shrike, *Lanius ludovicianus* (SC)
Lewis' woodpecker, *Melanerpes lewis* (SC)
long-billed curlew, *Numenius americanus* (SC)
white-faced ibis, *Plegadis chihi* (SC)
rufous hummingbird, *Selasphorus rufus* (SC)
red-breasted sapsucker, *Sphyrapicus ruber* (SC)
Bewick's wren, *Thryomanes bewickii* (SC)
California Thrasher, *Toxostoma redivivum* (SC)

Reptiles

northwestern pond turtle, *Clemmys marmorata marmorata* (SC)

southwestern pond turtle, *Clemmys marmorata pallida* (SC)

San Joaquin coachwhip (=whipsnake), *Masticophis flagellum ruddocki* (SC)

California horned lizard, *Phrynosoma coronatum frontale* (SC)

Amphibians

foothill yellow-legged frog, *Rana boylii* (SC)

western spadefoot toad, *Scaphiopus hammondii* (SC)

Fish

green sturgeon, *Acipenser medirostris* (SC)

river lamprey, *Lampetra ayresi* (SC)

Pacific lamprey, *Lampetra tridentata* (SC)

longfin smelt, *Spirinchus thaleichthys* (SC)

Invertebrates

Antioch Dunes anthicid beetle, *Anthicus antiochensis* (SC)

Sacramento anthicid beetle, *Anthicus sacramento* (SC)

brownish dubiraphian riffle beetle, *Dubiraphia brunnescens* (SC)

California linderiella fairy shrimp, *Linderiella occidentalis* (SC)

Plants

alkali milk-vetch, *Astragalus tener var. tener* (SC)

brittlescale, *Atriplex depressa* (SC)

valley spearscale, *Atriplex joaquiniana* (SC)

Snow Mountain buckwheat, *Eriogonum nervulosum* (SC)

adobe lily, *Fritillaria pluriflora* (SC)

drymaria dwarf-flax, *Hesperolinon drymarioides* (SC)

Hall's madia, *Madia hallii* (SC)

Ferris's milk-vetch, *Astragalus tener var. ferrisiae* (SC) *

Northern California black walnut, *Juglans californica var. hindsii* (SC) *

KEY:

(E)	*Endangered*	Listed (in the Federal Register) as being in danger of extinction.
(T)	*Threatened*	Listed as likely to become endangered within the foreseeable future.
(P)	*Proposed*	Officially proposed (in the Federal Register) for listing as endangered or threatened.
(PX)	*Proposed Critical Habitat*	Proposed as an area essential to the conservation of the species.
(C)	*Candidate*	Candidate to become a *proposed* species.
(SC)	*Species of Concern*	Other species of concern to the Service.
(D)	*Delisted*	Delisted. Status to be monitored for 5 years.
(CA)	*State-Listed*	Listed as threatened or endangered by the State of California.
*	*Extirpated*	Possibly extirpated from the area.
**	*Extinct*	Possibly extinct
	Critical Habitat	Area essential to the conservation of a species.